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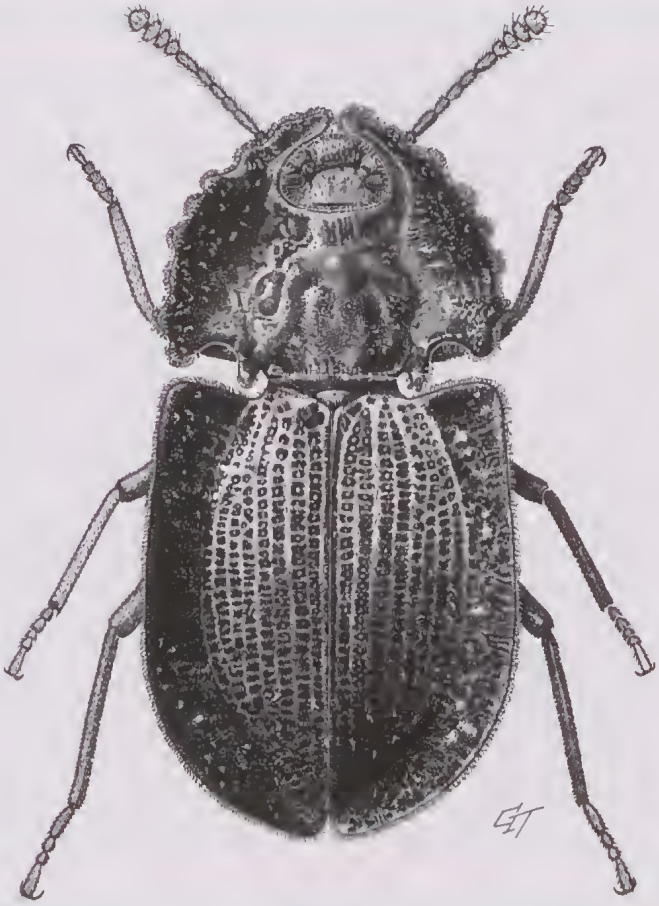

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THREE NEW ENDEMIC GENERA OF THE *ASTERON*-COMPLEX (ARANEAE: ZODARIIDAE) FROM AUSTRALIA: *BASASTERON*, *EUASTERON* AND *SPINASTERON*

BARBARA BAEHR

Baehr, B. 2003 06 30: Three new endemic genera of the *Asteron*-complex (Araneae: Zodariidae) from Australia: *Basasteron*, *Euasteron* and *Spinasteron*. *Memoirs of the Queensland Museum* 49(1): 1-27. Brisbane. ISSN 0079-8835.

Three new genera are created for 19 new species in the *Asteron*-complex, a large group of Australian Zodariidae. *Basasteron* gen. nov. contains only *Basasteron leucosemum* (Rainbow, 1920) and is characterised by the straight retrolateral cymbial flange and the very short ventral and dorsal tibial apophysis. *Euasteron* gen. nov. includes the type species *E. enterprise* sp. nov. (♂,♀) and *E. atriceps* sp. nov. (♂), *E. bartoni* sp. nov. (♂,♀), *E. carnarvon* sp. nov. (♂,♀), *E. churchillae* sp. nov. (♂), *E. gibsonae* sp. nov. (♂), *E. harveyi* sp. nov. (♂), *E. johannae* sp. nov. (♂,♀), *E. juliannae* sp. nov. (♂,♀), *E. krebsorum* sp. nov. (♂,♀), *E. lorne* sp. nov. (♂), *E. milledgei* sp. nov. (♂,♀), *E. monteithorum* sp. nov. (♂,♀), *E. raveni* sp. nov. (♂), *E. ulrichi* sp. nov. (♂), *E. ursulae* sp. nov. (♂,♀), *E. willeroo* sp. nov. (♂,♀) and can be recognised by cymbial flange with rounded extension. *Spinasteron* gen. nov. is identified by barely developed retrolateral cymbial flange and represented by *S. sanford* sp. nov. (♂) and *S. nigriceps* sp. nov. (♂). ❐ *Basasteron, Euasteron, Spinasteron, Australia, new genera.*

Barbara Baehr, Queensland Museum, PO Box 3300, South Brisbane 4101, Australia (e-mail: BarbaraB@qm.qld.gov.au); 20 October 2002.

This is the fourth systematic paper, funded by the Australian Biological Resources Study Participatory Program, on the large *Asteron*-complex (Baehr & Joqué, 1996). *Asteron* Joqué 1991, has been revised (Joqué & Baehr, 2001) and contains 8 species. From the different characters of all other species new genera were erected. So far, *Cavasteron*, *Leptasteron*, *Minasteron*, *Pentasteron*, *Phenasteron Psendasteron* and *Subasteron* (Baehr & Joqué, 2000, 2001; Joqué & Baehr, 2001) have been revised. This paper contains another 3 new genera with 19 new species. *Basasteron* shares the straight cymbial flange with the basic genera *Pentasteron*, *Phenasteron* and *Leptasteron* of the *Asteron*-complex and the semicircular DTA with folded distal part with the more derived genera *Cavasteron*, *Minasteron*, *Euasteron* and *Spinasteron*.

Euasteron and *Spinasteron* are closely related to *Cavasteron* and *Minasteron* sharing the special shape of tibial apophyses with 2 apophyses forming a deep concavity between them: the dorsal one divided in two parts connected by a ridge and the typical membranous semicircular DTA with folded distal part. *Euasteron* can be easily separated from both genera by the lack of a large terminal claw-like spine in male palps. *Spinasteron* is separated from these genera by the barely developed retrolateral cymbial flange (Fig. 4A) on the palpal cymbium in contrast to flange with a well-developed extension (Fig. 4C).

Most species are named in honour of people who supported this paper.

MATERIAL AND METHODS

Descriptions are generated with the aid of Intkey (Dallwitz et al., 1998) and shortened where possible.

Drawings were done from body, right palp, epigyne and vulva. All measurements are in mm.

Detailed spination of legs were not done because there are normally no characters to separate the species. Obvious spination characters are mentioned when they are important for separation of species.

Colour pattern is described from preserved spiders in alcohol. The white abdominal patches can be yellow or orange in live spiders. If the specimens are not well preserved they can loose their colour pattern completely. That happened mainly both in specimens stored in vials with white lids and in specimens that were collected in long-term pitfall traps using ethylene glycol. In these cases, the colour pattern is useless and the species can be identified only by their genitalic characters.

Abbreviations of characters: ALE, anterior lateral eyes; AME, anterior median eyes; AS, anterior spinnerets; CD, copulatory duct; CO,

copulatory opening; Ceph, cephalothorax; DTA, dorsal tegular apophysis; DtiA dorsal tibial apophysis; E, embolus; EP, external prong on dorso-retrolateral tibial apophysis; F, flange on cymbium; FA, frontal appendage of embolus base = VTA (ventral tegular apophysis); Fe, femur; IP, internal prong on dorso-retrolateral tibial apophysis; MS, median spinnerets; MEG, median eye group; ML, membranous lamella on retrolateral part of DTA; MT, metatarsus; P, patella; PE, prolateral extension of DTA; PR, prong on retrolateral side of DTA; PLE, posterior lateral eyes; PME, posterior median eyes; PS, posterior spinnerets; RE, rounded extension on flange; S, spermatheca; sl/sw sternum length/ sternum width; SP, sperm duct; T, tibia; Ta, tarsus; TBE, Trans basal area of embolus; TF, transparent field on embolus base; VtiA, ventral tibial apophysis.

Abbreviations of institutions where material was borrowed: AM, Australian Museum, Sydney (M. Gray); CSIRO, (T. Churchill); MAGNT, Museum & Art Gallery of the Northern Territory, Darwin; QM, Queensland Museum, Brisbane (R. Raven); SAMA, South Australian Museum, Adelaide (D. Hirst); VM, Melbourne Museum, Melbourne (C. McPhee); WAM, Western Australian Museum, Perth (M. Harvey).

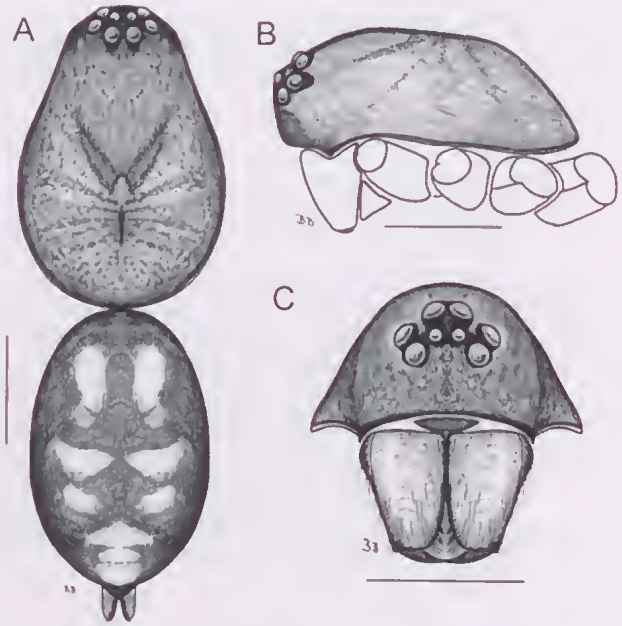

FIG. 1. *Basasteron leucosemum* (Rainbow, 1920). A, body dorsal, B,C, cephalothorax; B, lateral; C, frontal. Scale 1mm.

SYSTEMATICS

KEY TO *BASASTERON*, *EUASTERON* AND *SPINASTERON*

1. Palp, cymbial flange, barely developed, AME big (Figs 2A-C, 3C,F) 2

   Palp, cymbial flange, well developed either straight or with rounded extension RE (Figs 3D,F, 4C) 3

2. Carapace dark brown, SP only partly crossing TF (Figs 3C,D) . . . . . *Spinasteron sanford*

   Carapace yellow and dark cephalic area, SP crossing TF (Figs 2A-C, 3E,F) . . . . . *Spinasteron nigriceps*

3. Cymbium with straight retrolateral flange, DTA short , AME small (Figs 1, 3A,B) . . . . . *Basasteron leucosemum* (Rainbow, 1920)

   Cymbial flange with rounded extension, DTA long, AME small, big or equal (Figs 4C, 5A-C, 6A-C) . . *Euasteron*

Basasteron gen. nov.

TYPE SPECIES. *Basasteron leucosemum* (Rainbow, 1920).

ETYMOLOGY. *Basasteron* refers to the fact that this genus is a link between the basic genera *Pentasteron*, *Phentasteron*, *Leptasteron* and *Euasteron*.

REMARKS. Joequé (1995) tentatively added this species to *Nostera*. Because of the absence of the males he had no clue to which genus the species belonged. The newly described males from recently collected material show that the species belongs to the base of the *Asteron*-complex.

DIAGNOSIS. AME smallest; recognised mainly by characters from the male palp: tibia with short ventrolateral and dorsolateral apophysis cymbial flange straight, DTA short, semicircular, with distal part folded containing embolus; prolateral extension PE short, lying in cymbium; retrolaterally with membranous lamella; sperm duct S-shaped, partly crossing transparent field.

DESCRIPTION. Medium-sized (4.0-5.0), with finely reticulated tegument. Carapace widest at coxae II. Profile flat with highest point between fovea and PME (Fig. 1A).

Colour: carapace orange brown; sternum yellow; chelicerae orange; maxillae and labium yellow, distally white; abdomen dorsally sepia brown with 2-3 pairs of white patches on anterior part and 1-2 in front of spinnerets; laterally with 2 to 3

white patches; ventrally dark brown, mottled with white; legs yellow.

Eyes (Fig. 1A-C): in three rows (2-4-2). Only ALE in first row, AME (in the middle) and PLE in second, third only PME. AME smallest; eye group width about half of headwidth. MEG slightly longer than wide. Clypeus straight, about 3 times diameter of ALE high. Chilum single. Chelicerae as usual for family with a few hairs in front and dense row on distal promargin; no teeth. Maxillae and labium triangular; sparsely haired; maxillae with anteromesal scopula. Sternum flat; heart-shaped with straight anterior margin, shiny; with long setae around margin.

Legs: formula 4123. Spination: few spines on pairs I, II, more numerous on III, IV. Paired tarsal claws with numerous (ca. 10) teeth. Unpaired claw toothless, on very small onychium. Metatarsal preening brush on Mt II and III poorly developed.

Abdomen: oval; without sigilla. Spinnerets: AS short, conical, with very short distal segment; MS and PS tiny. Colulus represented by group of setae. Tracheal spiracle slit-like covered by posterior sclerotised lip with small stout spines.

Male palp (Fig. 3A,B): tibia with short dorsolateral and ventrolateral apophysis shallow concavity in between. Cymbium with simple unmodified straight flange, several spines near distal tip. DTA semicircular, distally folded with short prolateral extension. Embolus semicircular conducted by DTA.

Female leetotype described in Jocque, 1995.

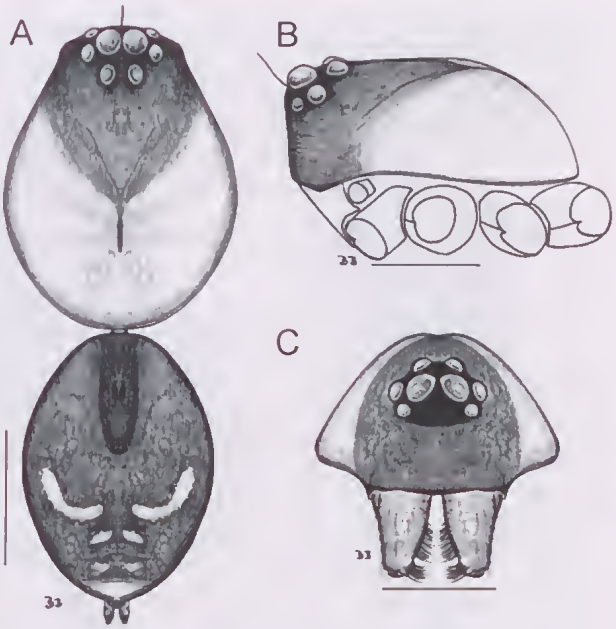

FIG. 2. *Spinasteron nigriceps*. A, body dorsal, B,C, cephalothorax; B, lateral; C, frontal. Scale 1mm.

Basasteron leucosemum (Rainbow, 1920) (Figs 1, 3A,B, 18)

Storena leucosemum Rainbow, 1920: 237 (description of f)
Nostera leucosemum Jocqué, 1995: 154 (comb. nov.)

MATERIAL. New South Wales: 3♂, Lord Howe I., North Bay West End, litt, 31°33'S, 159°05'E, 19 Dec1979, GM (QM S47393); Lord Howe I., 31°33'S, 159°05'E (AM KS15672); ♂, Lord Howe I., southern end of Salmon Beach in vicinity of Little Island, 31°34'08"S, 159°04'28"E, 19-28 Febr 2001, pitfall (AM KS82348); ♀, Lord Howe I., W slope of Dawsons Point Ridge, closed rainforest, 31°31'12"S, 159°02'27"E, 20 Nov 2000 (AM KS75769); ♂, Lord Howe I., Stephens Reserve, New Settlement, 31°31'12"S, 159°02'27"E 4-14 Dec 2000, pitfall (AM KS76265); ♂, Lord Howe I., behind beach at Old Gulch, W footslopes, 31°30'53"S, 159°02'36"E, 2-11 Dec2 000, pitfall (AM KS75879); 2♀, Lord Howe I., Stn 9, SE slope of Kim's Lookout, 31°30'54"S, 159°03'06"E, 31 Jan 1971, M. Gray (AM KS15618); 2♀, Lord Howe I., Stn 8 summit of Kim's Lookout, 31°30'54"S, 159°03'00"E, M. Gray 31 Jan 1971 (AM KS15617).

DIAGNOSIS. AME small, carapace orange brown, abdomen with 3 pairs of white patches on anterior part and 1-2 in front of spinnerets, palp with straight flange, DTA short circular, distally part folded containing embolus. Dorsolateral and ventrolateral tibial apophysis short.

DESCRIPTION. *Male* (holotype). Total length 4.56; ceph 2.48 long, 1.6 wide, 1.04 high; cl/cw 1.55; sternum 1.12 long, 0.96 wide; sl/sw 1.17; abdomen 2.08 long, 1.4 wide.

Colour: carapace orange brown; sternum yellow; chelicerae orange; maxillae and labium yellow, distally white; abdomen sepia brown, dorsally with 3 pairs of white patches on anterior part and 1-2 in front of spinnerets; laterally with 2-3 elongate and broad white patches; ventrally mottled with white; legs yellow to orange-brown.

Eyes: in 3 rows (2-4-2); AME smallest; eye group width 0.53 of headwidth; AME 0.1; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eye spaces AME-PME 0.3;

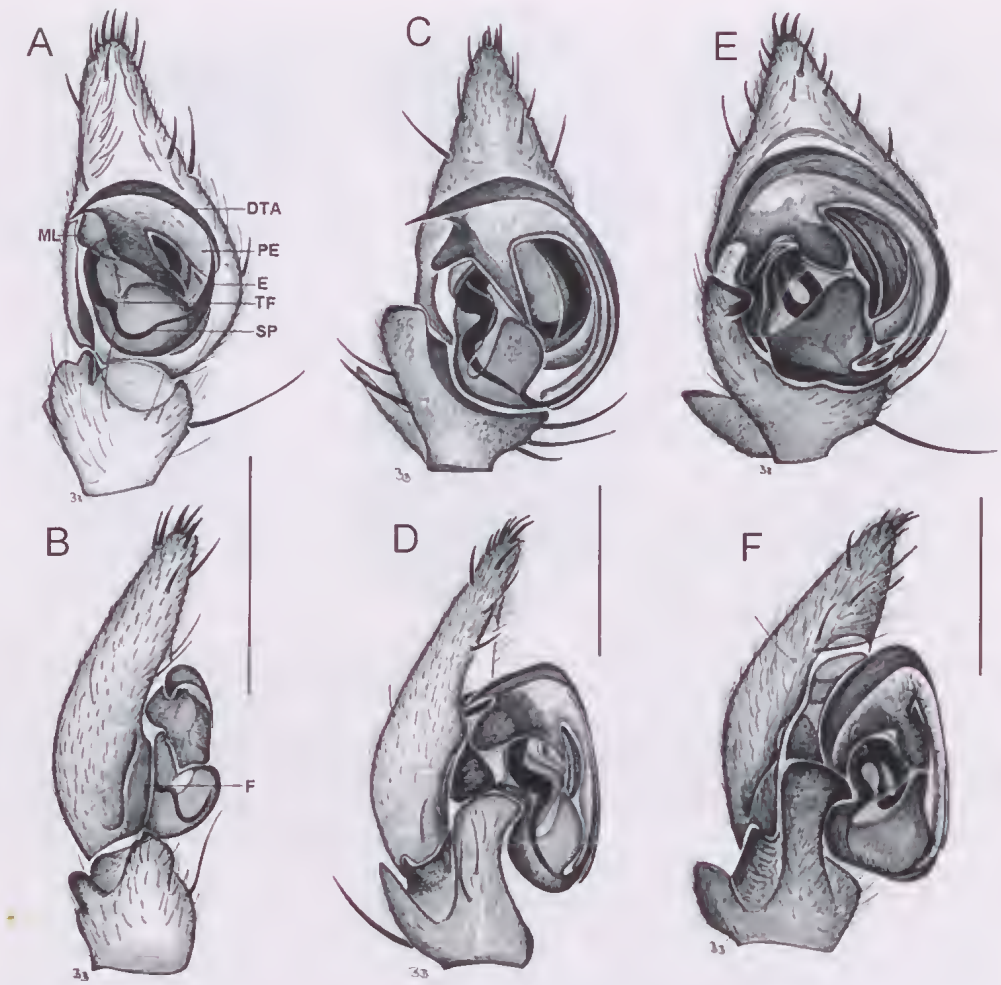

FIG. 3. *Basasteron*, *Spinasteron* spp. right male palps. A,B, *B. leucosemum*; A, ventral; B, retrolateral; C,D, *S. sanford*; C, ventral; D, retrolateral; E,F, *S. nigriceps*; E, ventral; F, retrolateral. Scale 0.5mm.

AME-AME 0.24; PME-PME 0.28. Clypeus 0.32mm high.

Abdomen: tracheal spiracle small, slit-like, covered with small stout spines.

Legs: femur I-II with 1 row, III, IV with 2 rows of long thin setae ventrally.

Male palp (Fig. 3A,B): tibia with short dorsolateral and ventrolateral apophysis shallow concavity in between. Cymbium F straight; DTA semicircular, distal part folded, prolateral extension short, lying in cymbium, retrolaterally with membranous lamella; SP duct S-shaped, partly crossing TF.

Female. Lectotype described in Joequé, 1995.

Variation: minor variation in the abdominal pattern as well as in size. Specimens from Kims Lookout and Old Gulch are slightly smaller and have 2 pairs of white dots on top of the abdomen. These specimens may belong to a second species but only further material will solve this problem.

DISTRIBUTION. Known only from Lord Howe Island (Fig. 18).

Spinasteron gen. nov.

TYPE SPECIES. *Spinasteron nigriceps* sp. nov.

ETYMOLOGY. For the very long, spinuous prong or end on palpal DTA retrolaterally.

DIAGNOSIS. Apart from the characters typical for the *Asteron*-complex, representatives of *Spinasteron* are recognised by AME biggest (Fig. 2A-C), but mainly by characters from the male palp (Figs 3C-F, 4A): cymbial flange barely developed with small knob; tibia, DtiA with short IP and longer EP; VtiA normally longer than EP of DtiA. DTA semicircular, with distal part folded containing embolus; PE retrolateral with long spinuous end, and normally with strong spinuous prong; SP S-shaped, partly or totally crossing TF. Base of embolus broad, TBE thin or broadened.

DESCRIPTION. Medium-sized (4.00-5.00), with finely reticulated tegument. Carapace at frontal part broad, with edges widest at coxae II. Profile flat, with highest point between fovea and PME (Fig. 2A-C).

Colour: carapace yellow to sepia brown; sternum yellow to orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen dorsally with scutum sepia brown; with 1-3 pairs of white patches on anterior part and 1 in front of spinnerets or chevrons; legs yellow to medium brown with or without colour pattern.

Eyes (Fig. 1A-C) in three rows (2-4-2). Only ALE in first row, AME (in the middle) and PLE in second, third only PME. AME biggest; eye group width more than half of headwidth. Clypeus straight, between 2.5 and 3 times diameter of ALE high. Chilum single. Chelicerae as usual for family, with a few hairs in front and dense row on distal promargin; no teeth. Maxillae and labium triangular, sparsely haired; Maxillae with anteromesal scopula. Sternum heart-shaped, with straight anterior margin, shiny, with long setae around margin.

Legs: formula 4123. Spination: few spines on pairs I, II, more numerous on III, IV. Femur I,II with 1 row of long thin setae ventrally, Femur III, IV with 2 rows of long thin setae ventrally. Metatarsal preening brush on Mt II and III poorly developed. Paired tarsal claws with numerous (ca. 10) teeth. Unpaired claw toothless, on very small onychium.

Abdomen oval, with scutum, without sigilla. Spinnerets: AS short, conical, with very short distal segment; MS and PS tiny. Colulus represented by group of setae. Tracheal spiracle slit-like covered by posterior sclerotised lip.

Male palp (Fig. 3C-F): Cymbial flange barely developed, with small knob; tibia, DtiA with short IP and longer EP. DTA semicircular, with distal part folded, containing embolus; PE long, not lying in cymbium, sometimes reaching tibia; retrolateral with long spinuous end, normally with strong spinuous prong; SP S-shaped, partly or totally crossing TF. Base of embolus broad, TBE with or without keel.

Female unknown.

Spinasteron sanford sp. nov.
(Figs 3C,D, 21)

ETYMOLOGY. For the type locality, Mount Sanford Station, Northern Territory. Noun in apposition.

MATERIAL. HOLOTYPE: ♂, Mt Sanford Station, NATT, Clay site, pitfall traps, 17°18'25"S, 130°46'28"E, 3-9 Jul 96, T. Churchill (CSIRO A763ex). PARATYPES: Northern Territory: ♂, as for holotype (CSIRO A763ex); 9♂, same locality, Loam site, 17°18'29"S, 130°45'17"E, Apr 97 (CSIRO A3496); ♂, same locality, Oct 97 (CSIRO A1057); 2♂, same locality, 3-9 Jul 96 (CSIRO A754); ♂, same locality, Jul 96 (CSIRO A764). 25m, Mt Sanford Station, NATT, Sand site, 17°21'26"S, 130°49'36"E, Apr 97 (CSIRO A3499); 3♂, same locality, 3-9 Jul 96 (CSIRO A756); 3♂, same locality, Oct 97 (CSIRO A3502); 3♂, same locality, 3-9 Jul 96 (CSIRO A754); ♂, Daly R., Quadrat G4, PWCNT, 17°21'26"S, 130°49'36"E, Jun 99 (CSIRO A2539); ♂, Kidman Springs, Grazing Gradient, Site 3, pitfall traps, 16°07'29"S, 130°56'25"E, Apr 98 (CSIRO A1320).

DIAGNOSIS. Differs from *S. nigriceps* by carapace dark brown, abdomen dark brown with scutum and 1 pair of white spots on posterior part and 1 in front of spinnerets, SP S-shaped, crossing only partly TF.

DESCRIPTION. *Male* (holotype). Total length 4.76; ceph 2.36 long, 1.68 wide, 1.04 high; cl/cw 1.4; sternum 1.12 long, 1 wide; sl/sw 1.12; abdomen 2.4 long, 1.6 wide.

Colour: carapace sepia brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with scutum and 1 pair of white spots on posterior part and 1 in front of spinnerets; legs medium brown, with darker brown lateral stripes; with indistinct colour pattern; coxae I-IV pale; trochanter I-IV brown; femur I dark brown, distally white, II-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.71 of headwidth; AME 0.2; ALE 0.18; PME 0.18; PLE 0.18; AME-AME 0; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.46; AME-AME 0.4; PME-PME 0.44. Clypeus: 0.48mm high.

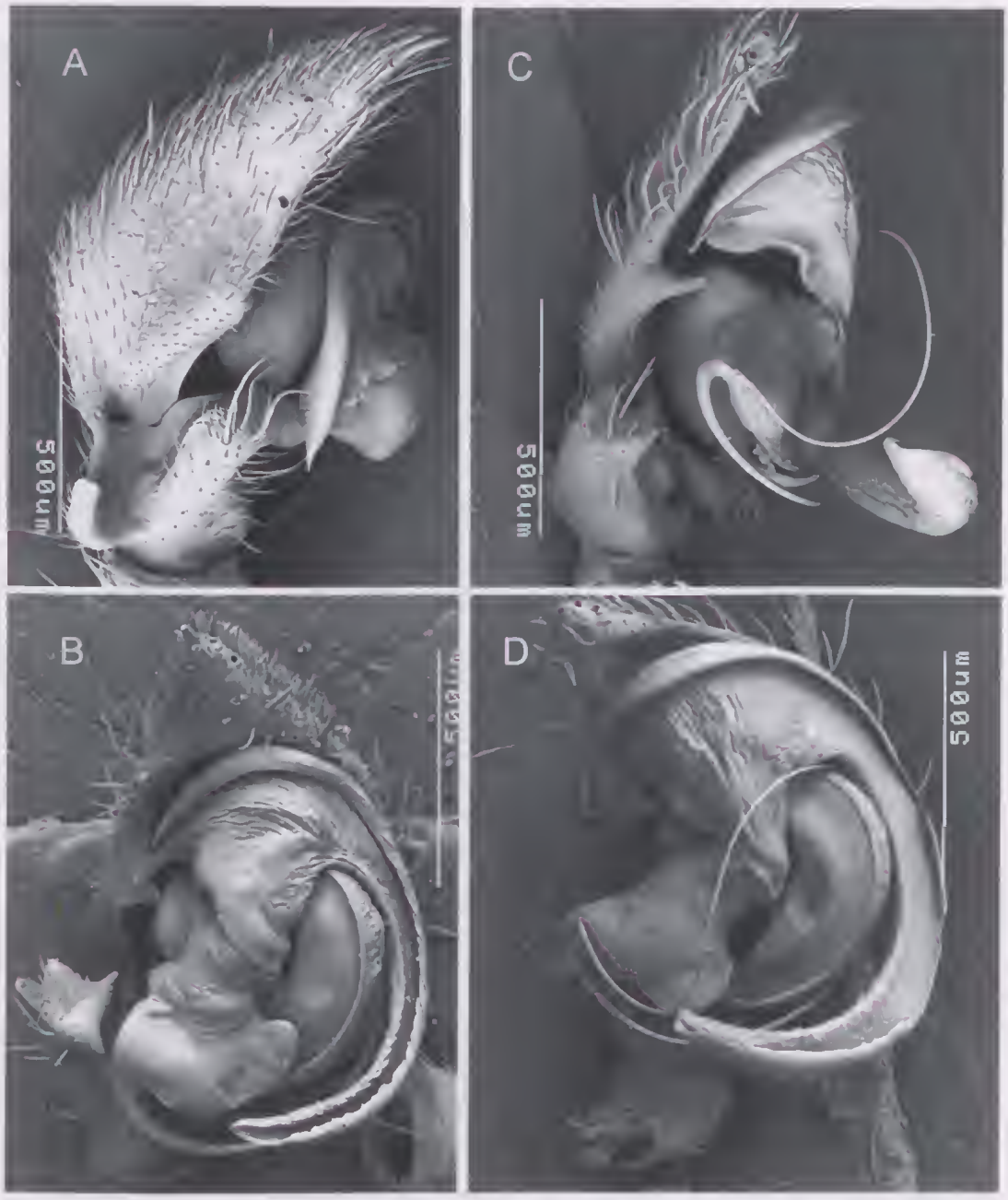

FIG. 4. *Euasteron*, *Spinasteron* spp. right male palps. A, *S. sanford*, retrolateral; B, *E. carnarvon* ventral; C,D, *E. enterprise*, C, retrolateral; D, ventral. Scale 0.5mm.

Male palp (Fig. 3C,D): DTA PE reaching tibia; SP S-shaped, partly crossing TF; DtiA IP much shorter than EP, both with sharp tip; VtiA long, straight, with blunt tip.

Female unknown.

DISTRIBUTION. Northern Territory, Mount Sanford Station (Fig. 21). Semi-arid grassland

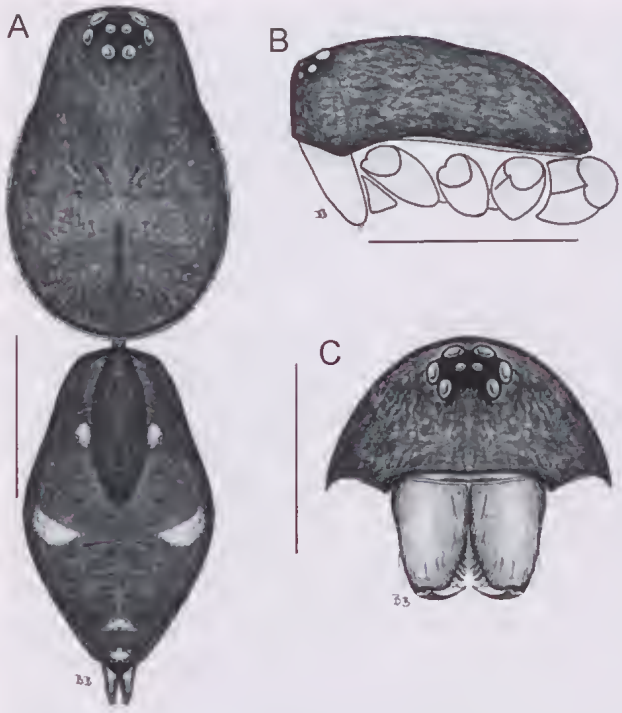

FIG. 5. *Euasteron enterprise*. A, body dorsal, B,C, cephalothorax; B, lateral; C, frontal. Scale 1mm.

and tropical savanna, with barley mitchell grass (*Astrebla pectinata*) and Vertisols soil.

Spinasteron nigriceps sp. nov.
(Figs 3E,F, 21)

ETYMOLOGY. For the dark cephalic area. Latin *nigriceps*, black-headed.

MATERIAL. HOLOTYPE: ♂, Daly river, NT, Quadrat G4, PWCNT, pitfall traps, 17°21'26"S, 130°49'36"E, Jun 99, T. Churchill (CSIRO A2539cx). PARATYPES: Northern Territory: ♂, L10, PWCNT pitfall traps, 14°58'61"S, 132°.01'60"E, 16 Jun 99, T. Churchill (CSIRO A3429); ♂, Douglas Daly, Sand Site, pitfall traps, 13°53'36"S, 131°15'55"E, 3-9 Jul 96 (CSIRO A0332); ♂, same locality, Grid 1 (CSIRO A177).

DIAGNOSIS. Differs from *S. sanford* by: carapace yellow with dark cephalic area, abdomen with scutum and 3 pairs of white spots on posterior part and 1 in front of spinnerets, SP crossing TF totally.

DESCRIPTION. *Male* (holotype). Total length 4.2; ceph 2.2 long, 1.68 wide, 0.96 high; cl/cw 1.31; sternum 0.96 long, 0.88 wide; sl/sw 109; abdomen 2 long, 1.28 wide.

Colour: carapace yellow with dark cephalic area; sternum yellow; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with scutum, 3 pairs of white patches on anterior part and 1 in front of spinnerets; laterally, ventrally pale brown; legs yellow.

Eyes: AME largest; eye group width 0.66 of headwidth; AME 0.18; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.08; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.4; AME-AME 0.4; PME-PME 0.36. Clypeus: 0.48mm high.

Male palp (Fig. 3E,F): DTA, PE reaching tibia; retrolaterally with strong prong; SP S-shaped, crossing transparent field totally; DtiA IP tiny, EP short blunt; VtiA long, straight, with rounded tip.

Female unknown.

DISTRIBUTION. Northern Territory (Fig. 21). Tropical savanna.

Euasteron gen. nov.

TYPE SPECIES. *Euasteron enterprise* sp. nov.

ETYMOLOGY. Latin, Eu = real.

DIAGNOSIS. Cymbium with retrolateral extension or lobe. *Euasteron* differs from *Cavasteron* and *Minasteron* by the lack of the large terminal palpal claw in males. Females of *Euasteron* still have this huge terminal claw with 4-6 teeth. Epigyne copulatory ducts are more elongate and coiled than in *Cavasteron* and *Minasteron*.

DESCRIPTION. Medium-sized (3.4-6.2) with finely reticulated tegument. Carapace widest at coxae II. Profile flat with highest point between fovea and PME (Figs 5,6).

Colour: carapace yellow, orange or sepia brown; abdomen pale or sepia brown with or without scutum, with 1-3 pairs of white patches on anterior part and 1-3 in front of spinnerets, or with pale or dark chevrons; legs yellow to dark brown; clearly annulated or without colour pattern.

Eyes (Figs 5A-C, 6A-C) in three rows (2-4-2). Only ALE in first row, AME (in the middle) and PLE in second, third only PME. AME smallest, equal to others or largest; eye group width between 0.47 and 0.66 of head width. MEG slightly longer than wide, or as long as wide. Clypeus straight, about 3 times diameter of ALE

high. Chilum single. Chelicerae as usual for family, with a few hairs in front and dense row on distal promargin; no teeth. Maxillae and labium triangular; sparsely haired; maxillae with anteromesal scopula. Sternum heart-shaped, with straight anterior margin, shiny; with long setae around margin.

Legs: formula 4123. Spination: few spines on pairs I, II, more numerous on III, IV. Paired tarsal claws with numerous (ca. 12) teeth on inner side of paired claws (Fig. 7B). Unpaired claw toothless, on very small onychium. Metatarsal preening brush on Mt II and III poorly developed. Female palp with big claw and 4-6 teeth (Fig. 7D).

Abdomen: oval, with or without scutum. Spinnerets: AS short, conical, with very short distal segment; MS and PS tiny. Colulus represented by group of setae. Tracheal spiracle slit-like, covered by posterior sclerotised lip, with or without small stout spines.

Male palp (Figs 8-14): Tibia short, with 2 apophyses forming deep concavity between them, dorsally divided in two parts and connected by a ridge; internal prong (IP) long, short or absent; external prong (EP) long or short; ventrolateral tibial apophyses hooked or bird-head-shaped. Cymbial flange with rounded extension. DTA, semicircular, distally folded with prolateral extension (PE) not reaching or reaching tibia, retrolaterally, with membranous lamella or strong prong. Embolus thin, semicircular, conducted by DTA.

Epigyne (Figs 15-17): with 1 or 2 copulatory openings, with U- or V-shaped sclerotised tubes; copulatory ducts elongate, coiled, ending in small or bigger spermathecae.

KEY TO SPECIES GROUPS OF *EUASTERON*

1. All eyes equal in size; base of embolus with extremely long semicircular FA; DTA with strong prong, epigyne with 2 big oval CO, not attached to epigastric fold, CO straight elongate coiled, ending in separated spermathecae. (Figs 12A,B, 16A,B) . . . . . *E. willeroo*

   AME smaller, or bigger than other eyes, FA shorter not semicircular, epigyne different (Figs 8-11,13,14, 15A-F, 16C-F, 17A-H) 2

2. AME smaller than other eyes, eye group width > 0.55 (Fig. 5A-C) . . . . . *E. enterprise*-group

   AME bigger than other eyes, eye group width < 0.55 (Fig. 6A-C). . . . . *E. juliannae*-group

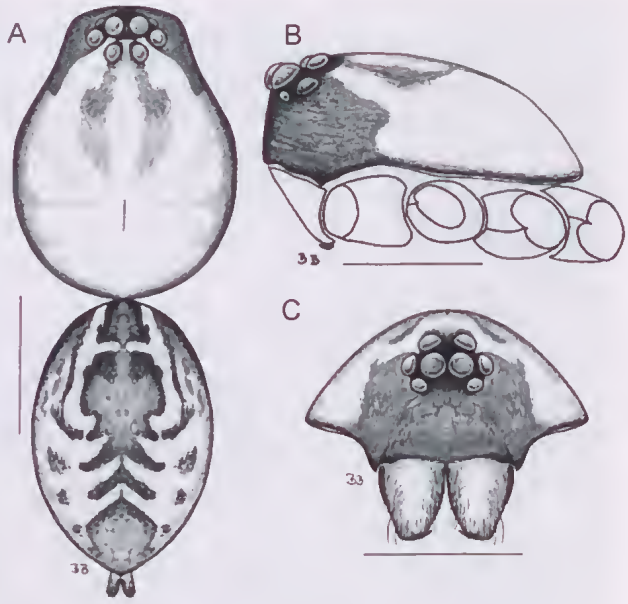

FIG. 6. *Euasteron carnarvon*. A, body dorsal, B,C, cephalothorax; B, lateral; C, frontal. Scale 1mm.

Euasteron willeroo sp. nov.
(Figs 12A,B, 16A,B, 19)

ETYMOLOGY. For the type locality.

MATERIAL. HOLOTYPE: ♂, Willeroo, NT, NAT, Clay site, pitfall traps, 15°11'26"S, 131°36'42"E, 3-9 Jul 96, T. Churehill (CSIRO A0343). PARATYPES: Northern Territory: ♀, as for holotype (CSIRO A0343); 4♀, same locality (CSIRO A3506); ♀, same locality (CSIRO A981); 11♂, same locality, Oct 97 (CSIRO A1173); 3♂, same locality, Apr 97 (CSIRO A983); 7♂, same locality, 15°11'26"S, 131°36'42"E, Oct 97 (CSIRO A1163); 2♂, Barkly Tablelands, Hayfield, Mitchel grassland, site 3, pitfall traps, Dec 95 (CSIRO A2116); ♂, Mt Sanford Station, Grazing, VRD, Site 2, pitfall traps, 17°18'25"S, 130°46'28"E, Apr 98 (CSIRO A1350); 7♂, Mt Sanford Station, NAT, Clay site, 17°18'25"S, 130°46'28"E, Oct 97 (CSIRO A3501); 4♂, same locality, Apr 97 (CSIRO A35030); 12♂, same locality, Jul 96 (CSIRO A762); 10♂,1♀, same locality, Jul 96 (CSIRO A763); 8♂, same locality, 3-9 Jul 96 (CSIRO A761); 3♂, Kidman Springs, NAT, Clay site, pitfall traps, 16°06'39"S, 130°56'55"E, Oct 97 (CSIRO A1121); ♂, same locality, Apr 97 (CSIRO A3504); 3♂, same locality, Oct 97 (CSIRO A3505); 7♂, same locality, Jul 96 (CSIRO A752); 7♂, same locality, Grid 3, 3-9 Jul 96 (CSIRO A755).

DIAGNOSIS. Eyes equal sized. Carapace sepia brown, abdomen sepia brown with 1 pair of white patches on posterior part and 1 in front of spinnerets. Palp, base of embolus with extremely

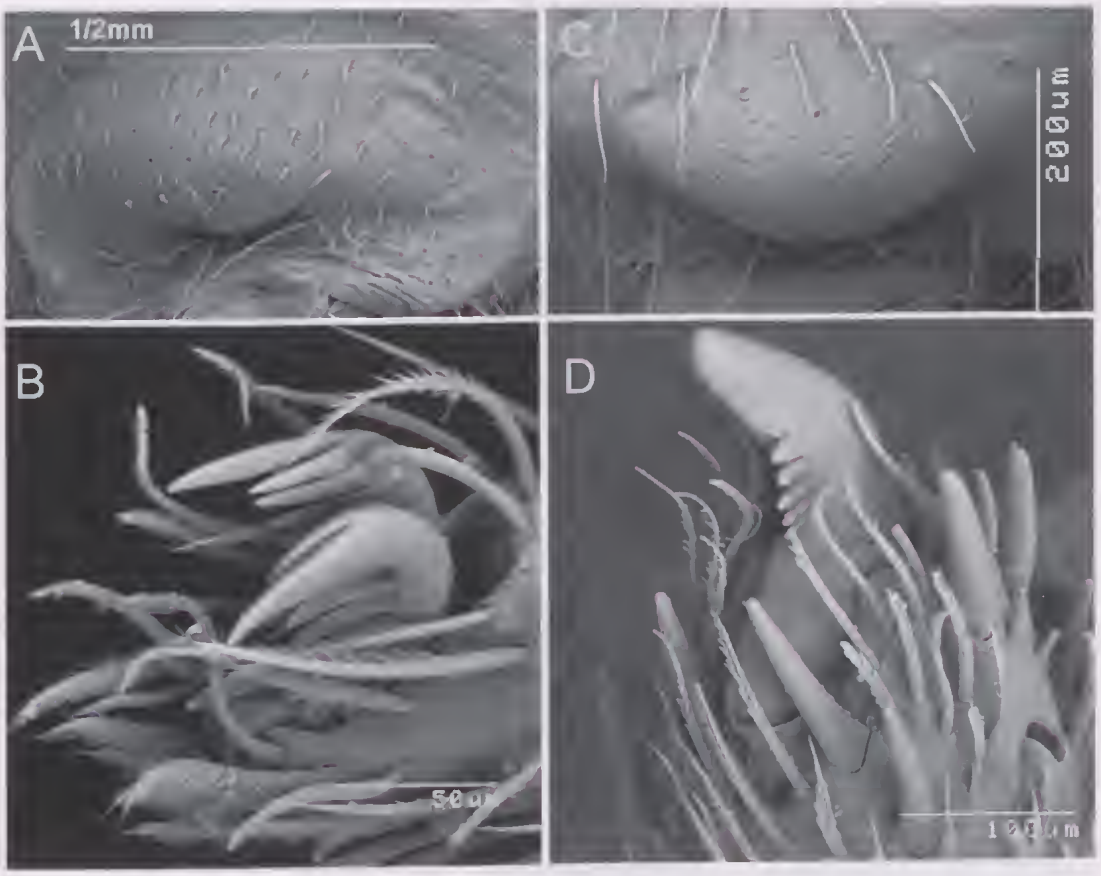

FIG. 7. *Euasteron*, spp. A,B,D, *E. carnarvon*; A, tracheal spiracle; B, tarsal claw 1 right leg; D, female palpal claw retrolateral; C, *E. enterprise*, tracheal spiracle.

long and bent FA. With 2 big oval CO, not attached to epigastric fold.

DESCRIPTION. *Male* (holotype). Total length 3.48; ceph 1.76 long, 1.28 wide, 0.72 high; cl/cw 1.37; sternum 0.92 long, 0.8 wide; sl/sw 1.15; abdomen 1.72 long, 1 wide.

Colour: carapace, sternum, chelicerae sepia to medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with 1 pair of white spots on posterior part and 1 in front of spinnerets; legs pale brown, darker brown lateral stripes; with indistinct colour pattern; coxae, trochanter I-IV pale; femur I dark brown, II-IV proximal part white, distal part dark brown.

Eyes: equal sized; eye group width 0.58 of headwidth; AME 0.1; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.3; AME-AME 0.22; PME-PME 0.24. Clypeus: 0.36mm high.

Male palp (Fig. 12A,B): DTA, PE reaching tibia; retrolaterally with strong prong; VTA =FA elongate, sickleshaped; sperm duct S-shaped, not crossing TF; DtiA 1P 3times as long as wide, EP long sticking out: VtiA bird-head-shaped.

Female (paratype) (Fig. 16A,B). Total length 4; ceph 2.04 long, 1.28 wide, 0.72 high; cl/ew 1.59; sternum 0.84 long, 0.8 wide; sl/sw 1.05; abdomen 1.96 long, 1.28 wide.

Colour: as in males, carapace sometimes orange brown.

Eyes: equal sized; eye group width 0.51 of headwidth; AME 0.1; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.3; AME-AME 0.22; PME-PME 0.24.

Clypeus 0.36mm high.

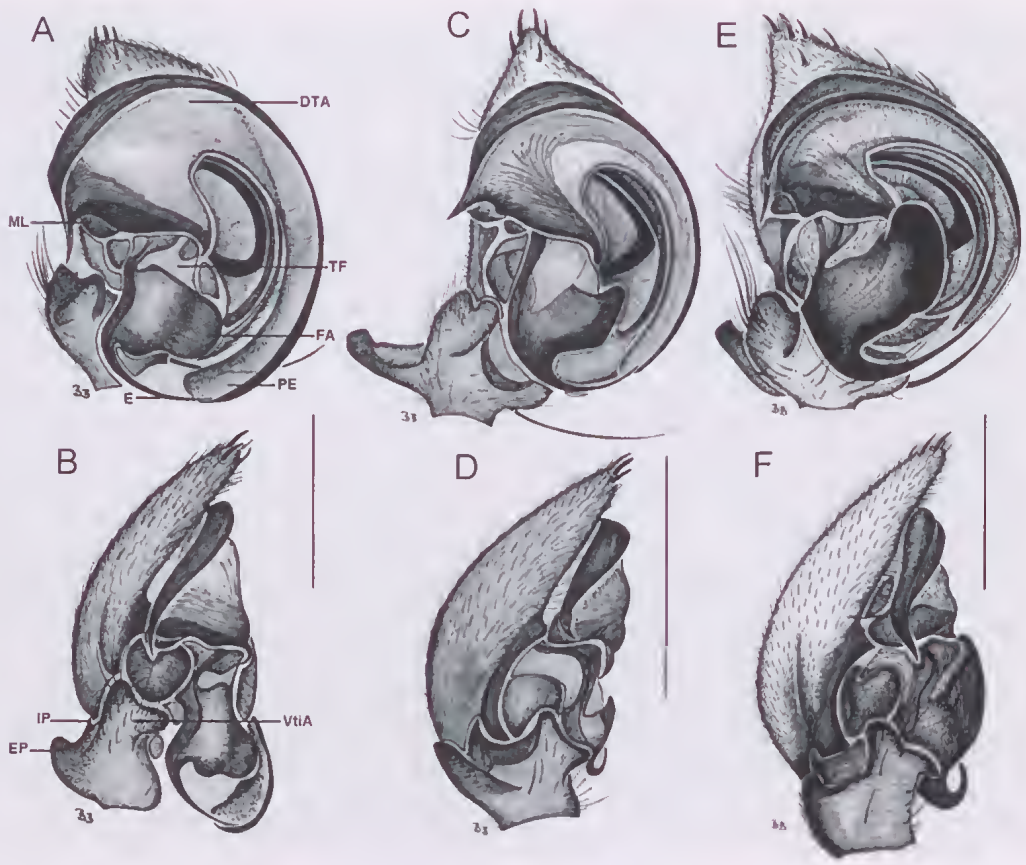

FIG. 8. *Euasteron* spp. right male palps. A,B, *E. enterprise*; A, ventral; B, retrolateral; C,D, *E. monteithorum*; C, ventral; D, retrolateral; E,F, *E. milledgei*; E, ventral; F, retrolateral. Scale 0.5mm. DTA = dorsal tegular apophysis; E = embolus; EP = external prong on dorso-retrolateral tibial apophysis (DtiA); FA = frontal appendage of embolus base = VTA (ventral tegular apophysis); IPML = internal prong on DtiA; membranous lamella on retrolateral part of DTA; PE = prolateral extension of DTA; TF = transparent field on embolus base; VtiA = ventral tibial apophysis.

Epigyne (Fig. 16A,B): with 2 big oval CO, not attached to epigastric fold; CD elongate, coiled about straight axis, ending in separated S.

DISTRIBUTION. Northern Territory (Fig. 19). Semi-arid, desert.

KEY TO SPECIES OF *EUASTERON ENTERPRISE* GROUP

Males

1. Carapace orange or orange brown 2
   Carapace dark brown. 4
2. Abdomen laterally with 2 pairs of white spots. Palp, tibial apophyses dorsolaterally, with external prong long sticking out (Fig. 8C,D) . . . . . *E. monteithorum*
   Abdomen laterally with 1 white spot. Palp, tibial apophyses dorsolaterally, with external prong short not sticking out (Figs 9A,B, 10A,B) 3
3. Palp; DTA retrolaterally with folded, retrolateral directed prong (Fig. 9A,B) . . . . . *E. lorne*
   Palp; DTA retrolaterally with sharp basal directed prong (Fig. 10A,B) . . . . . *E. bartoni*
4. Palp without or with short FA directed prolatrally on base of embolus (Figs 8A,B, 10C,D) 5
   Palp with big FA directed distally (Figs 8E,F, 9C,D) . . 6
5. Abdomen with 1 big pair of white patches on anterior part and 1 elongate white stripe in front of spinnerets; palp without FA; DTA retrolaterally with big prong (Fig. 10C,D) . . . . . *E. gibsonae*
   Abdomen with scutum, 2 pairs of white spots on anterior part and 2-3 white spots in front of spinnerets; palp with short rounded FA directed prolaterally; DTA retrolaterally with lamella (Fig. 8A,B) . . *E. enterprise*
6. Palp, DTA retrolaterally with lamella and small prong; FA big, wider than long; dorsolateral tibial apophysis internal prong short (Fig. 8E,F) . . . . . *E. milledgei*

Palp, DTA retrolaterally with big prong; FA big longer than wide; dorsolateral tibial apophysis internal prong 3 times long as wide (Fig. 9C,D) . . . . . *E. krebsorum*

Females

1. Carapace orange or orange brown 2
   Carapace dark brown. 3
2. Epigyne with 2 small, semicircular CO (Fig. 15C,D); abdomen laterally with 2 pairs of white spots . . . . . *E. monteithorum*
   Epigyne with 1 broadly oval CO and long U-shaped sclerotised tubes (Fig. 16C,D); abdomen laterally with 1 big white spot and pale booklungs . . . . . *E. bartoni*
3. Epigyne SP touching; CO broadly oval internal (Fig. 16E,F) . . . . . *E. krebsorum*
   Epigyne SP separated at least 1 diameter depart; CO very small or inverted flask-shaped (Fig. 15A,B,E,F) . . . 4
4. Epigyne with 1 small oval CO and long thin V-shaped sclerotised tubes; CD, inverted V-shaped, SP about 1 of their diameter apart (Fig. 15A,B) . . . . . *E.enterprise*
   Epigyne, CO inverted flask-shaped, wide U-shaped sclerotised tubes, CO straight; SP twiee their diameter apart (Fig. 15E,F) . . . . . *E. milledgei*

Euasteron enterprise sp. nov.
(Figs 5, 4 C,D, 7C,D 8A,B 15A,B, 18)

ETYMOLOGY. From type locality, a proposed mine site on North Stradbroke Island. Noun in apposition.

MATERIAL. HOLOTYPE: ♂, SE Qld, N. Stradbroke I, Enterprise, Blackbutt 2, 60m, night coll, 27°34'S, 153°27'E. 7-14 Jan 2002, R.Raven & B.Baehr (QM S55531). PARATYPES: Queensland: ♂ SE Qld, Mt Cotton, 200m, rainforest, intercept trap G Monteith (QM S44277); ♀ SE Qld, N. Stradbroke I, Enterprise, Blackbutt 1, 90m, night coll, 27°33'S, 153°28'E, 7 -14 Jan 2002, R.Raven & B.Baehr (QM S55596); ♂, Mt Cotton, upper gully, Flight/Int, 27°36'S, 153°13'E, 12 Dec 97-7 Mar 98, G Monteith (QM S47571); ♂, Kenilworth State Forest, Sunday Ck Rd, 9.8km W of Charlie Moreland Park, wet sclerophyll, 26°40'11"S, 152°36'35"E, 7 May 1998, G Milledge (AM KS55660); ♀, same locality, Junction with Gigher Creek Rd, 26°41'54"S, 152°33'5"E, 7.5.1998, G Milledge (AM KS55661); ♂, Little Yabba Ck, rainforest, 26°37'S, 152°41'E, 30 Nov 91-7 Jan 92, D.J. Cook (QM S25198); ♂, SE Qld, Mt Tamborine, 670m, rainforest, UNLO, 27°56'S, 153°12'E, 10 Jul 74, V.Davies, R.Raven, C.L. Wilton (QM S4357); ♂, NE Qld, Maalan Rd, 2km S Palmerston H'way, PYKN, 17°36'S, 145°42'E, 18 May 1995, G Monteith (QM S41058); ♂, NE Qld, Bellenden Ker Ra,1/2km S Cabletower 7, Earthwatch Expedition & Qld Museum, rainforest, 500m, PYKN, 17°16'S, 145°51'E, 17-24 Oct 1981 (QM S27615); ♂, NE Qld O'Donogue's Falls, 150m on tree, 16°26'S, 145°20'E, 15 May 1995, G Monteith, Pyretrum (QM S43294); ♂, ME Qld, Crediton, Complex Notophyl vine forest, 950m, on tree trunk, 21°13'S, 148°34'E, 14-21 Sep 75, R.Kohout & V.Davies (QM S4451); ♂, Millstream Conservation Pk., PYKN, 17°32'S, 145°30'E, 6 Dec 98, G& S. Monteith (QM S47574).

DIAGNOSIS. AME smallest. Carapace sepia bown, abdomen sepia brown with scutum and 2 pairs of white patches on anterior part and 2-3 in front of spinnerets. Palp DTA retrolaterally with membranous lamella only. Epigyne, copulatory duets elongate coiled, inverted V-shaped.

DESCRIPTION. *Male* (holotype). Total length 4.16; ceph 2.08 long, 1.04 wide, 0.76 high; cl/cw 1.48; sternum 1.04 long, 0.92 wide; sl/sw 1.13; abdomen 2.08 long, 1.28 wide.

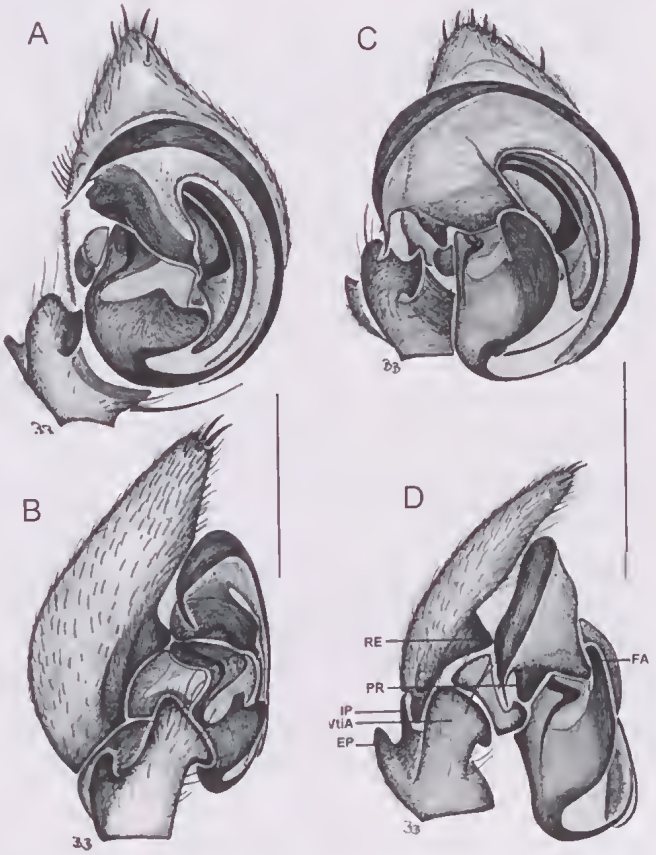

FIG. 9. *Euasteron* spp. right male palps. A,B, *E. lorne*; A, ventral; B, retrolateral; C,D, *E. krebsorum*; C, ventral; D, retrolateral. Scale 0.5mm. PR = prong on retrolateral side of DTA; RE = rounded extension on flange.

Colour: carapace, sternum and chelicerae sepia brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with scutum, with 2 pairs of white patches on anterior part, with 2 in front of spinnerets; laterally with 1 white patch; ventrally pale brown to dark brown; legs medium brown, annulated; coxae I-IV white or pale; trochanter I-IV brown; femur I dark brown, with proximal white patch, II-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes (Fig. 5A-C): AME smallest; eye group width 0.51 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.26; AME-AME 0.16; PME-PME 0.24. Clypeus: 0.36mm high.

Abdomen: tracheal spiracle small slit-like, with sclerotised cover.

Male palp (Fig. 8A,B): DTA: PE not reaching tibia, retrolaterally with membranous lamella; VTA =FA short, rounded, SP not crossing TF; tibia short; IP tiny, EP short, blunt; VtiA bird-head-shaped.

Female (paratype). Total length 4.24; ceph 2.08 long, 1.28 wide, 0.84 high; cl/cw 1.62; sternum 0.92 long, 0.84 wide; sl/sw 1.09; abdomen 2.16 long, 1.32 wide.

Colour: as in male but abdomen without scutum.

Eyes: In rows (2-4-2); AME smallest; eye group width 0.5 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.26; AME-AME 0.16; PME-PME 0.24. Clypeus: 0.36mm high.

Epigyne (Fig. 15A,B): With 1 small, oval CO, with long, V-shaped, sclerotised tubes; CD elongate coiled, inverted V-shaped, ending in small, separated S. Female palpal claw strong with more than 4 teeth.

Variation: Some specimens are slightly smaller than HT. Variation in colour: Carapace with or without dark fovea and bifurcate stripes, abdomen with 1 or 2 white spots in front of spinnerets and on femur I the proximal part can be white.

DISTRIBUTION. Wet Tropics to Southern Queensland (Fig. 18). Rainforest.

Euasteron bartoni sp. nov.
(Figs 10A,B, 16C,D, 21)

ETYMOLOGY. For N. Barton, the collector of the types.

MATERIAL. HOLOTYPE: ♂, Lucknow area, Vic., Oct 1979, 37°49'S, 147°39'E, 10.1979, N. Barton (AM KS83927). PARATYPES: Victoria: ♀, as for holotype (AM KS84124).

DIAGNOSIS. Similar to *E. krebsorum* with AME smallest; abdomen with 2 pairs of white patches and 1 patch in front of spinnerets; booklungs pale. Palp DTA retrolaterally with strong prong. Epigyne with 1 broadly oval semicircular CO and long, U-shaped, sclerotised tubes; CD elongate, coiled, straight, ending in small, separated spermathecae. Separated from *E. krebsorum* by abdomen with only 1 spot in front of spinnerets and FA short, not bent.

DESCRIPTION. *Male* (holotype). Total length 3.6; ceph 1.68 long, 1.2 wide, 0.68 high; cl/ew 1.4; sternum 0.8 long, 0.72 wide; sl/sw 1.11; abdomen 1.48 long, 0.92 wide.

Colour: carapace orange brown; with dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown, with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets; laterally with 1 big white patch and pale booklungs; ventrally dark brown; legs medium brown, with darker brown lateral stripes; clearly annulated; coxae I-IV white; trochanter I-IV medium to dark brown; femur I, II dark brown, III, IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.54 of headwidth; AME 0.06; ALE 0.08; PME 0.08; PLE 0.08; AME-AME 0.04; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.06; ALE-PLE 0.02; eyes group AME-PME 0.24; AME-AME 0.16; PME-PME 0.2. Clypeus: 0.28mm high.

Male palp (Fig. 10A,B): DTA, PE not reaching tibia; retrolaterally with strong prong; SP S-shaped, not crossing TF; tibia, IP as long as EP, blunt, VtiA short, hooked.

Female (paratype). Total length 3.8; ceph 1.88 long, 1.2 wide, 0.68 high; cl/cw 1.57; sternum 0.84 long, 0.76 wide; sl/sw 1.11; abdomen 1.92 long, 1.24 wide.

Colour: as in males.

Eyes: AME smallest; eye group width 0.52 of headwidth; AME 0.06; ALE 0.08; PME 0.08; PLE 0.08; AME-AME 0.04; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.08; ALE-PLE

0.02; eyes group AME-PME 0.28; AME-AME 0.16; PME-PME 0.2. Clypeus 0.3mm high.

Epigyne (Fig. 16C,D): with 1 broadly oval CO attached to epigastric fold and long, U-shaped, sclerotised tubes; CD elongate, coiled about straight axis, ending in small separated S.

DISTRIBUTION. Victoria (Fig. 21).

Euasteron gibsonae sp. nov.
(Figs 10C,D, 21)

ETYMOLOGY. For Leslie Gibson, the collector of the types.

MATERIAL. HOLOTYPE. ♂, SW Qld, Astraleba Downs NP., pitfall traps, 24°13'05"S, 140°34'48"E, Sep.1997, L.Gibson (QM S55533). PARATYPES: Queensland: ♂, as for holotype (QM S55532). Northern Territory: 8♂, Barkly Tablelands, Connells Lagoon, Mitchell grassland, Quadrat 1, pitfall traps, 18°52'S, 136°32'E, Mar 96, T.B. Churchill, A. Fisher (CSIRO A643); 3♂, same locality, Helen Springs Stn., Quadrat 1, 28°24'S, 133°52'E (CSIRO A0431); ♂, same locality, Birrindudu, site 4, 18°24'S, 129°26'E, Apr 96, T.B. Churchill, A. Fisher (CSIRO A1449); ♂, same locality, Kirkimbie, site 4, 17°44'S, 129°14'E, Jun 95, T.B. Churchill, A. Fisher (CSIRO A1465); ♂, same locality (CSIRO A1460).

DIAGNOSIS. AME small. Carapace sepia bown, abdomen sepia brown with 1 big pair of white patches on anterior part and 1 elongate in front of spinnerets. Tibial apophysis, IP short EP short blunt.

DESCRIPTION. *Male* (holotype). Total length 4.16; ceph 2.04 long, 1.56 wide, 0.8 high; cl/ew 1.31; sternum 0.92 long, 0.84 wide; sl/sw 1.09; abdomen 2.12 long, 1.28 wide.

Colour: carapace, sternum and chelicerae sepia brown; maxillae and labium medium brown, distally white; abdomen sepia brown, dorsally with 1 big pair of white patches on anterior part and 1 elongate white stripe in front of spinnerets; laterally sepia brown; ventrally dark brown; legs medium brown.

Eyes: AME smallest; eye group width 0.47 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.3; AME-AME 0.16; PME-PME 0.24. Clypeus: 0.4mm high.

Male palp (Fig. 10CD): DTA, PE not reaching tibia; retrolaterally with strong prong; SP not crossing transparent field; tibia short; IP short, EP short blunt; VtiA bird-head-shaped.

Female unknown.

DISTRIBUTION. SW Queensland to Barkly Tableland (Fig. 21). Grassland.

Euasteron krebsorum sp. nov.
(Figs 9C,D, 16E,F 18)

ETYMOLOGY. For K. & D. Krebs, collectors of the types.

MATERIAL. HOLOTYPE. ♂, Hay, NSW, 8km West of irrigation channel, grassland, pitfall traps, 33°3'S, 144°45'E, 19 Dec 97-9 Jan 98, K. & D. Krebs (QM S460984). PARATYPES: New South Wales: 2♂, as for holotype (QM S46736). South Australia: 50♂,2♀, Gawler, 16km, Open grassland, pitfall traps, 34°36'S, 138°55'E, 19 Dec 97-9 Jan 98, K. & D. Krebs (QM S46710); ♂,♀, same locality (AM KS84125).

DIAGNOSIS. Carapace sepia brown, abdomen sepia brown with 2 pairs of white spots on anterior part and 2 in front of spinnerets. AME small. DTA retrolaterally with prong. FA long directed distally.

DESCRIPTION. *Male* (holotype). Total length 3.56; ceph 1.84 long, 1.24 wide, 0.68 high; cl/ew 1.48; sternum 0.8 long, 0.72 wide; sl/sw 1.11; abdomen 1.72 long, 1 wide.

Colour: carapace sepia brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown, dorsally with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets; laterally with 1 white patch; ventrally dark brown; legs medium brown; with indistinct colour pattern; coxae I-IV white; femur I dark brown, II-IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.54 of headwidth; AME 0.08; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.06; ALE-PLE 0.02; eyes group AME-PME 0.26; AME-AME 0.18; PME-PME 0.24. Clypeus: 0.28mm high.

Male palp (Fig. 9C,D): DTA, PE not reaching tibia; retrolaterally with strong prong; VTA =FA elongate directed distally, SP, not crossing TF; tibia short; IP longer than EP, sharp, EP blunt; VtiA hooked.

Female (paratype). Total length 3.56; ceph 1.84 long, 1.24 wide, 0.68 high; cl/ew 1.48; sternum 0.8 long, 0.72 wide; sl/sw 1.11; abdomen 1.72 long, 1 wide.

Colour: as in male.

Eyes: nearly equal sized, or AME smallest; eye group width 0.54 of headwidth; AME 0.08; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.04; PME-PLE

0.06; ALE-PLE 0.02; eyes group AME-PME 0.26; AME-AME 0.18; PME-PME 0.24. Clypeus: 0.28mm high.

Epigyne (Fig. 16EF): with 1 oval semicircular CO attached to epigastric fold and long V-shaped sclerotised tubes, CD elongate coiled, V-shaped. S touching.

DISTRIBUTION. South Australia, New South Wales (Fig. 18). Open forest and grassland.

Euasteron lorne sp. nov.
(Figs 9A,B, 18)

ETYMOLOGY. The species name is taken from the type locality. A noun in apposition.

MATERIAL. HOLOTYPE: ♂, Lorne State Forest near Taree, NSW, site 86(1) in litter, 29 Oct 78-10 Dec 79, 31°35'S, 150°23'E, 17.11.1978, D Milledge (AM KS15971). PARATYPES: New South Wales: 2♂, Lorne SF near Lorne site 86 (5), in litter, 29 Oct 78-10 Dec 79, 31°35'S, 152°57'E, 12.11.1978, D Milledge (AM KS16059); ♂, Lorne SF near Lorne site 86 (5), in litter. 29 Oct 78-10 Dec 79, 31°35'S, 152°57'E, 12.11.1978, D Milledge (QM S60817).

DIAGNOSIS. AME small. Carapace orange, legs yellow orange, abdomen sepia brown, with 2 pairs of white patches on anterior part and 3 in front of spinnerets. Palp DTA with folded prong.

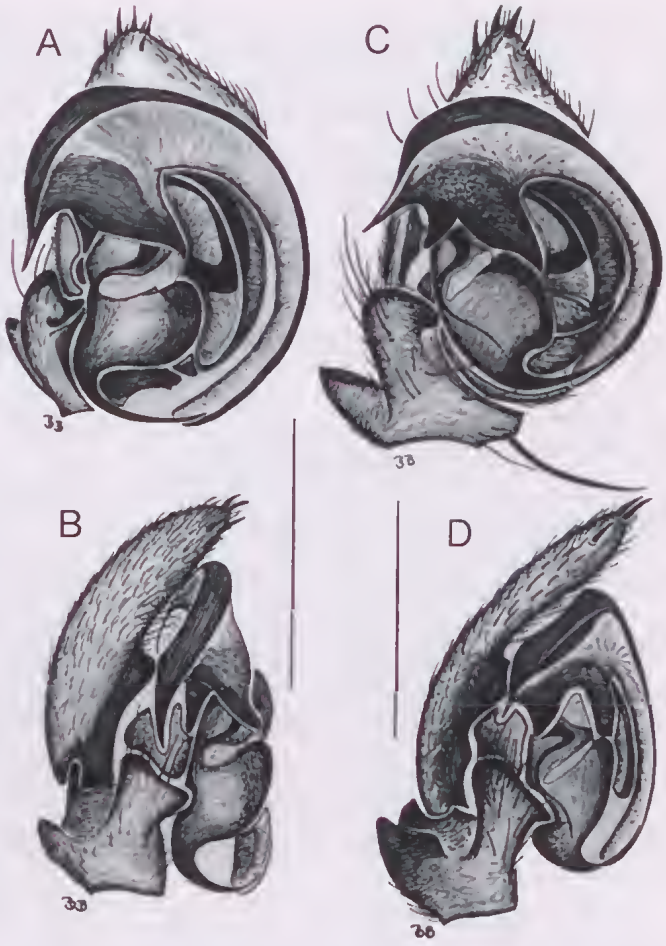

FIG. 10. *Euasteron* spp. right male palps. A,B, *E. bartoni*; A, ventral; B, retrolateral; C,D, *E.gibsonae*; C, ventral; D, retrolateral. Scale 0.5mm.

DESCRIPTION. *Male* (holotype). Total length 4.16; ceph 2.12 long, 1.6 wide, 1 high; cl/cw 1.32; sternum 1.0 long, 0.96 wide; sl/sw 1.04; abdomen 2.04 long, 1.32 wide.

Colour: carapace, sternum and chelicerae orange; maxillae and labium orange, distally white; abdomen sepia brown, dorsally with 2 pairs of white patches on anterior part and 3 in front of spinnerets, laterally with 1 white patch; ventrally dark brown; legs yellow.

Eyes: AME smallest; eye group width 0.48 of headwidth; AME 0.06; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.1; ALE-PLE 0.04; eyes group AME-PME 0.3; AME-AME 0.16; PME-PME 0.28. Clypeus: 0.4mm high.

Male palp (Fig. 9A,B): DTA PE not reaching tibia; retrolaterally with folded prong; FA short, directed prolaterally; SP S-shaped, not crossing TF; tibia short; 1P absent, EP short blunt; VtiA hooked.

Female unknown.

DISTRIBUTION. Lorne State Forest, New South Wales (Fig. 18). Coastal forest.

Euasteron milledgei sp. nov.
(Figs 8E,F, 15E,F, 18)

ETYMOLOGY. For D. Milledge, one of the collectors of the types.

MATERIAL. HOLOTYPE: ♂, Gibraltar Ra, NSW, lower rainforest, 450m, pitfall traps 29°35'S, 152°13'E, 30 Mar-10 Nov 1980, G. & S. Monteith (QM S4261). PARATYPES: New South Wales: ♂, Bruxner Pk, via Coffs Harbour, rainforest, 150m, pitfall traps, 30°14'S,

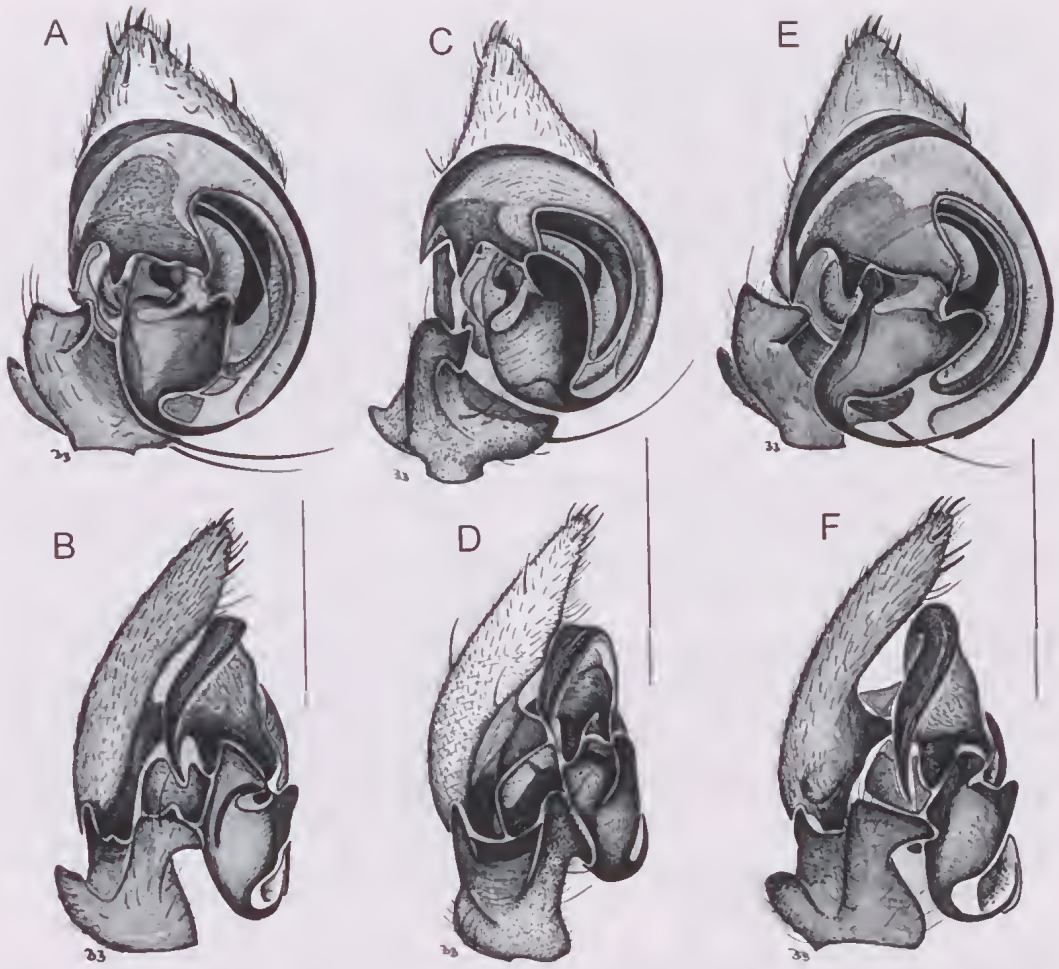

FIG 11. *Euasteron* spp. right male palps. A,B, *E. raveni*; A, ventral; B, retrolateral; C,D, *E. harveyi*; C, ventral; D, retrolateral; E,F, *E. churchillae*; E, ventral; F, retrolateral. Scales 0.5mm.

153°06'E, 22 Mar-13 Nov 80, G. & S. Monteith (QM S3744); ♂, Dorrigo Nat Pk, Never Never area, Sassafras Ck, wet temperate rainforest, 30°22'S, 152°45'E, 7 Dec 92, D.J. Bickel, (AM KS35052); ♂, Lome SF near Lome site 86(1), litter, 29 Oct 78-10 Dec 79, 31°35'S, 152°57'E, 4.11.1979, D. Milledge (AM KS5607); ♂, ♀ same locality, 4 Nov 79 (AM KS5633); ♂, same locality, 12 Nov 78 (AM KS16060).

DIAGNOSIS. AME small. Carapace sepia brown, abdomen sepia brown with 2 pairs of white spots on anterior part and 3-4 in front of spinnerets. Palp, DTA retrolaterally with small lamella and short prong. Epigyne, CO inverted flask-shaped

DESCRIPTION. *Male* (holotype). Total length 4.28; ceph 2.24 long, 1.68 wide, 1.08 high; cl/cw 1.33; sternum 0.88 long, 0.84 wide; sl/sw 1.04; abdomen 2.04 long, 1.4 wide.

Colour: carapace sepia brown; with dark fovea and dark bifureate patches in front; sternum orange brown; chelicerae medium brown; maxillae and labium orange, distally white; abdomen sepia brown, dorsally with 2 pairs of white patches on anterior part and 3 in front of spinnerets, laterally with 3 elongate and broad white patches; ventrally with 1 longitudinal white stripe from epigastric fold to near tracheal spiracle; legs yellow; clearly annulated; coxae I-IV white or pale; trochanter I-IV medium to dark brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.53 of headwidth; AME 0.08; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.1; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.2; PME-PME 0.28. Clypeus: 0.44mm high.

Male palp (Fig. 8E,F): DTA, PE not reaching tibia; retrolaterally with membranous lamella and short prong; FA big, flat, with rounded tip, directed distally, SP not crossing TF; tibia short; IP tiny, EP short, VtiA hooked.

Female (paratype). Total length 4.8; ceph 1.96 long, 1.38 wide, 1 high; cl/ew 1.44; sternum 0.84 long, 0.8 wide; sl/sw 1.05; abdomen 2.84 long, 2 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.53 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.1; ALE-PLE 0.04; eyes group AME-PME 0.3; AME-AME 0.16; PME-PME 0.26.

Epigyne (Fig. 15E,F): CO inverted flask-shaped, with U-shaped sclerotised tubes, copulatory ducts elongate coiled. Spermatheeae twice their diameter apart.

DISTRIBUTION. NE New South Wales (Fig. 18).

HABITAT. Rainforest.

Euasteron monteithorum sp. nov.
(Figs 8C,D, 15B,E, 18)

ETYMOLOGY. For Dr Geoff and Sybil Moneith of the Queensland Museum, the collectors of the holotype.

MATERIAL. HOLOTYPE: ♂, Poverty Point, NSW, 20km SE Tenterfield, rainforest, 945m, 29°08'S, 152°07'E, 3 Oct 78-21 Feb 79 G&S. Monteith (QM S12149). PARATYPES: New South Wales: ♂, as for holotype (QM S3772); ♂, Whian Whian SF, rainforest, 210m pitfall traps, 28°41'S, 153°19'E, 19 Aug-16 Nov 74, G.& S. Monteith (QM S12135); ♂, same locality but 28°14'S, 153°19'E, 19 Aug-16 Nov 78, G.& S. Monteith (QM S3774); ♂ Victoria Pk, via Alstonville, rainforest, 250m, pitfall traps, 28°53'S, 153°23'E, 16 Nov-26 Dec 74, G. & S. Monteith (QM S12142); ♂, same locality but 26 Dec 1974-23 Mar 75, G. & S. Monteith (QM S12141); ♂,♀, same locality but (QM S12144). Queensland: ♂,♀, SE Qld, Kroombit Tops, rainforest, 1000m, pitfall traps, 24°22'S, 151°01'E, 22-26 Feb 82, G. Monteith, D. Yeates, G. Thompson (QM S3730).

DIAGNOSIS. AME small. Carapace orange brown, abdomen with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets. Palp, DTA retrolaterally with lamella; tibia IP short, sharp, EP blunt, sticking out. Epigyne with 2 small, semicircular CO.

DESCRIPTION. *Male* (holotype). Total length 3.76; ceph 1.96 long, 1.48 wide, 0.96 high; cl/ew 1.32; sternum 1.0 long, 0.88 wide; sl/sw 1.13; abdomen 1.8 long, 1.2 wide.

Colour: carapace orange brown; with dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae orange; maxillae and labium pale brown, distally white; abdomen sepia brown, dorsally with 2 pairs of big white patches on anterior part and 2-4 in front of spinnerets, laterally with 2 elongate white patches, first one larger; ventrally with 1 longitudinal white stripe from epigastric fold to near tracheal spiracle and 1 pair of white patches near tracheal spiracle; legs pale brown; with indistinct colour pattern; coxae I-IV white; trochanter I-IV white; femur I-IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.5 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.06; PME-PME 0.08; PME-PLE 0.04; ALE-PLE 0.04; eyes group AME-PME 0.24; AME-AME 0.16; PME-PME 0.24. Clypeus: 0.36mm high.

Male palp (Fig. 8C,D): DTA PE not reaching tibia; retrolaterally with membranous lamella; FA short, straight, with rounded tip; SP not crossing TF; tibia short; IP short, sharp; EP blunt sticking out; VtiA short, hooked.

Female (paratype). Total length 3.72; ceph 1.8 long, 1.28 wide, 0.84 high; cl/ew 1.4; sternum 0.88 long, 0.8 wide; sl/sw 1.1; abdomen 1.92 long, 1.48 wide.

Colour: as in males.

Eyes: AME smallest; eye group width 0.5 of headwidth; AME 0.06; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.08; PME-PLE 0.04; ALE-PLE 0.04; eyes group AME-PME 0.26; AME-AME 0.16; PME-PME 0.24. Clypeus: 0.36mm high.

Epigyne (Fig. 15B,E): With 2 small, semi-circular copulatory openings, copulatory ducts elongate coiled, ending in small spermatheeae.

DISTRIBUTION. Northeastern New South Wales and southern Queensland (Fig. 18). Rainforest.

KEY TO SPECIES OF *EUASTERON JULIANNAE* GROUP, MALES

1. DTA retrolaterally with strong prong (Figs 11, 12CD) . 2

DTA retrolaterally with lamella and without or only tiny prong (Figs 13, 14) 5

2. Carapace dark brown, abdomen with scutum, palp, FA long, straight, directed prolatero-distally (Fig. 11E,F) . . . . . *E. churchillae*

Carapace orange brown with dark fovea and bifurcate patches, abdomen without scutum, palp, FA short or long, bent and directed distally (Figs 11A-D, 12C,D) . 3

3. Abdomen laterally with 1 white patch, palp; DtiA EP long (Fig. 12C,D) . . . . . *E. ulrichi*

Abdomen laterally without any colour pattern, palp; DtiA EP short (Fig. 11A-D). 4

4. Femur I dark brown, palp, SP partly crossing TF, FA short (Fig. 11A,B).. . . . . *E. raveni*

Femur I proximally white, palp, SP partly crossing TF, FA long bent (Fig. 11C,D) . . . . . *E. harveyi*

5. Carapace yellow with dark margin and dark cephalic area; abdomen pale with dark chevrons (Figs 6A-C, 13C,F). 6

Carapace sepia or orange brown, abdomen sepia brown with 2 or 3 pairs of white spots on anterior part and 1-3 in front of spinnerets, or pale chevrons 7

6. Palp, SP not crossing TF; FA wider than long; (Fig. 13C,D) . . . . . *E. atriceps*

Palp, SP partly crossing TF, FA as long as wide (Fig. 13E,F) . . . . . *E. carnarvon*

7. Abdomen with pale chevrons; DtiA EP with deep incision, palp, SP not crossing TF (Fig. 13A,B) . . . *E. juliannae* . . . . . .

Abdomen with 2-3 pairs of white spots on anterior part and 3 in front of spinnerets; DtiA EP without deep incision , palp SP crossing TF completely (Fig. 4A-D) 8

8. Abdomen with 3 pairs of white spots on anterior part and 3 in front of spinnerets, palp, SP broad (Fig. 14A,B) . . . . . *E. johannae*

Abdomen with 2 pairs of white spots on anterior part and 3 in front of spinnerets; palp, SP narrow (Fig. 14C,D) . . . . . *E. ursulae*

Euasteron churchillae sp. nov.
(Figs 11E,F, 19)

ETYMOLOGY. In honour of Dr Tracey Churchill, the collector of the types and in esteem for her important ecological work on Australian spiders.

MATERIAL. HOLOTYPE: ♂, Daly River, NT, Quadrat C6, PWCNT, pitfall traps, 13°55'23"S, 131°24'06"E, 21.6.99, T. Churchill (CSIRO A2545). PARATYPES: Northern Territory: ♂, Daly R., Quadrat K10, PWCNT, 14°43'61"S, 132°37'03"E, 30 Aug 98 (CSIRO A3431).

DIAGNOSIS. AME biggest, carapace sepia brown, abdomen with scutum, with 2 pairs of white patches on anterior part and 2 in front of spinnerets. Palp, DTA with big prong, base of embolus with big straight FA.

DESCRIPTION. *Male* (holotype). Total length 3.24; carapace 1.64 long, 1.2 wide, 0.8 high; cl/cw 1.36; sternum 0.8 long, 0.72 wide; sl/sw 1.11; abdomen 1.6 long, 0.88 wide.

Colour: carapace sepia brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with scutum and 2 pairs of white patches on anterior part and 2 in front of spinnerets; laterally with 1 white patch; legs medium brown, with darker brown lateral stripes; clearly annulated; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.6 of headwidth; AME 0.13; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.3; AME-AME 0.26; PME-PME 0.24. Clypeus: 0.32mm high.

Male palp (Fig. 11E,F): DTA, PE not reaching tibia; retrolaterally with strong prong; FA elongate, straight, with rounded tip; SP not crossing TF; DtiA IP shorter than EP, Ep with blunt tip; VtiA birdhead-shaped.

Variation: the only other examined male (A3431) is about 1/3 longer than the HT with body length of 4.24mm and ceph length of 2.24mm. Body shape colour and palp shape are the same.

Female unknown.

DISTRIBUTION. Daly River area, Northern Territory (Fig. 19). Semi-arid area, desert.

Euasteron harveyi sp. nov.
(Figs 11C,D, 19)

ETYMOLOGY. In honour of Dr Mark Harvey of the Western Australian Museum, in esteem for his important work on Australian arachnids.

MATERIAL. HOLOTYPE: ♂, Marun CALM Site 8/4, 3.4km SW of Manning Ck, Prince Frederic Harbour 6, WA, malaise trap, 15°00'S, 125°21'E, 125°21'E, 11 Jun 88, I.D. Naumann (WAM T51851). PARATYPES: Western Australia: ♂, Marun CALM Site 8/4, 3.4km SW of Manning Ck, Prince Frederic Harbour 6, Malaise trap, 15°00'S, 125°21'E, 125°21'E, 11 Jun 88, I.D. Naumann (WAM T51852).

DIAGNOSIS. AME biggest, carapace orange brown, abdomen with with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets, differs from *E. raveni* in palp with long bent FA, SP not crossing TF.

DESCRIPTION. *Male* (holotype). Total length 3.4; ceph 1.6 long, 1.28 wide, 0.72 high; cl/cw 1.25; sternum 0.76 long, 0.72 wide; sl/sw 1.05; abdomen 1.8 long, 1.08 wide.

Colour: carapace orange brown; with dark fovea and dark bifurcate patches in front; sternum, chelicerae, maxillae and labium white to yellow; abdomen sepia brown; dorsally with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets; legs pale to white; clearly annulated; coxae I-IV white; trochanter I-IV white; femur I-IV proximal part white, distal part dark brown; tibia I-IV proximal and distal part brown, medial part white.

Eyes: AME largest; eye group width 0.55 of headwidth; AME 0.12; ALE 0.1; PME 0.1; PLE 0.1; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.26; PME-PME 0.24. Clypeus 0.32mm high.

Male palp (Fig. 11C,D): DTA, PE not reaching tibia; retrolaterally with strong prong; FA elongate, sickleshaped, with rounded tip; SP S-shaped, not crossing TF; DtiA IP about 3 times longer than wide, sharp, EP short, blunt; VtiA bird-head-shaped.

Female unknown.

DISTRIBUTION. Known only from type locality (Fig. 19).

Euasteron raveni sp. nov.
(Figs 11A,B, 19)

ETYMOLOGY. In honour of Dr Robert Raven of the Queensland Museum, in esteem for his important work on Australian spiders.

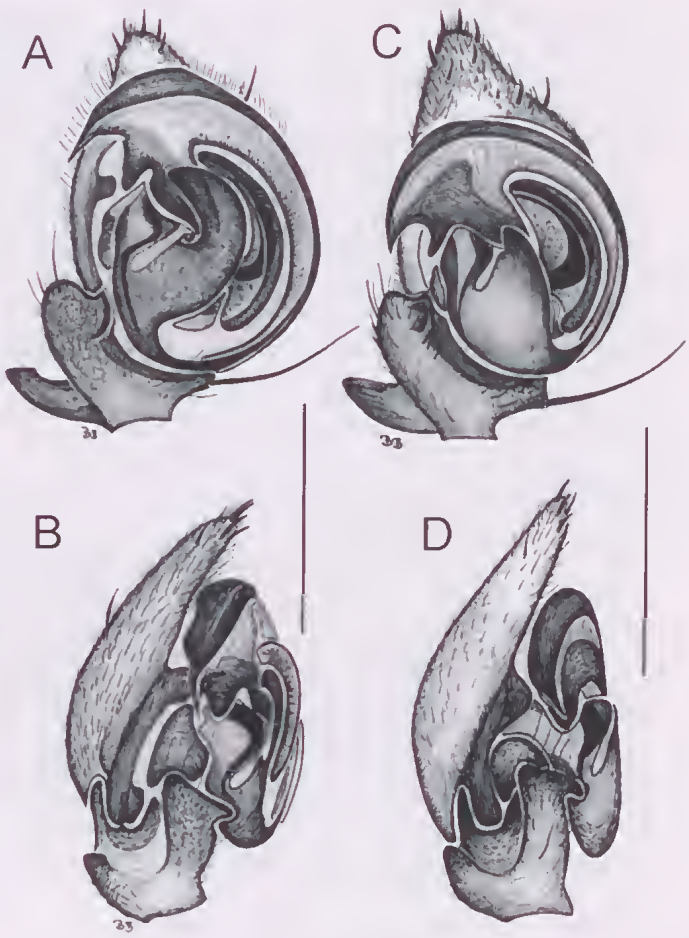

FIG. 12. *Euasteron* spp. right male palps. A,B, *E. willeroo*; A, ventral; B, retrolateral; C,D, *E. ulrichi*; C, ventral; D, retrolateral. Scales 0.5mm.

MATERIAL. HOLOTYPE: ♂, NW Qld, Mount Isa, 20°44'S, 139°29'E, Jan 1981, W. Myors (AM KS6448).

DIAGNOSIS. AME biggest, carapace orange brown, abdomen with with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets, palp with strong prong and short FE, SP partly crossing TF.

DESCRIPTION. *Male* (holotype). Total length 4.00; carapace 2.04 long, 1.52 wide, 0.8 high; cl/ew 1.34; sternum 0.96 long, 0.84 wide; sl/sw 1.14; abdomen 1.96 long, 1.24 wide.

Colour: carapace orange brown; with dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae orange; maxillae and labium orange, distally white; abdomen sepia brown; dorsally with 2 pairs of white patches on anterior part and 2-3 in front of spinnerets; ventrally pale brown; legs medium brown, with darker brown lateral stripes; clearly annulated; coxae I-IV white; trochanter I-IV brown; femur I dark brown, II-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.61 of headwidth; AME 0.14; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.02; eyes group AME-PME 0.38; AME-AME 0.28; PME-PME 0.28. Clypeus: 0.4mm high.

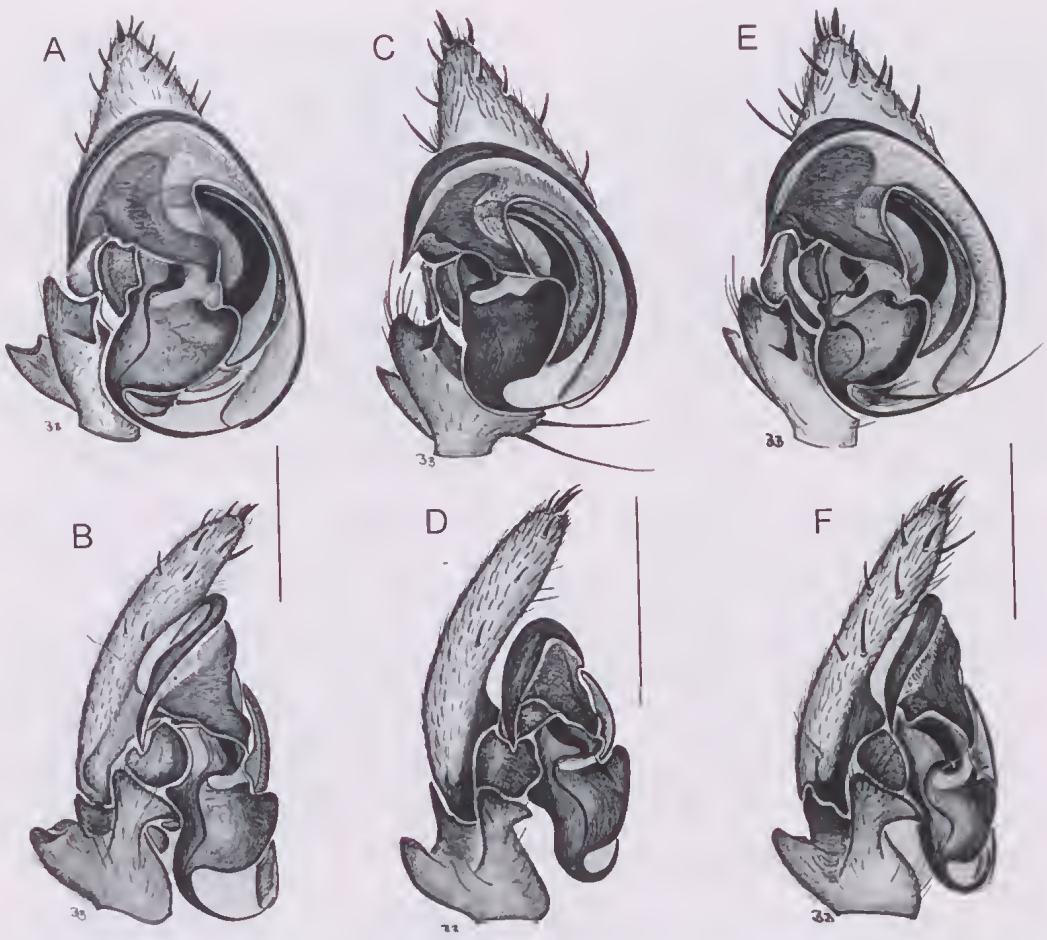

FIG. 13. *Euasteron* spp. right male palps. A,B, *E. juliannae*; A, ventral; B, retrolateral; C,D, *E. atriceps*; C, ventral; D, retrolateral; E,F, *E. carnarvon*; E, ventral; F, retrolateral. Scales 0.5mm.

Abdomen: tracheal spiracle small, slit-like, covered with small stout spines.

Male palp (Fig.11A,B): DTA, PE not reaching tibia; retrolaterally with strong prong; FA short, straight; SP S-shaped, partly crossing TF; DtiA, 1P 3 times as long as wide, sharp, EP blunt; VtiA bird-head-shaped.

Female unknown.

DISTRIBUTION. Known only from Mt Isa, NW Queensland (Fig. 19).

Euasteron ulrichi sp. nov.
(Figs 12C,D, 19)

ETYMOLOGY. For Ulrich Baehr, the author's son.

MATERIAL. HOLOTYPE: ♂, 26km E Napier Downs, WA, 17°15'S, 124°44'E, 24 Nov 1984, B. & M. Bachr (QM S55907).

DIAGNOSIS. AME biggest, carapace orange brown, abdomen with 2 pairs of white patches on anterior part and 1 in front of spinnerets. Palp DTA retrolaterally with strong prong, base of embolus with short straight FA directed distally.

DESCRIPTION. *Male* (holotype). Total length 3.6; ceph 1.84 long, 1.24 wide, 0.72 high; el/ew 1.48; sternum 0.8 long, 0.8 wide; sl/sw 1; abdomen 1.76 long, 1.04 wide.

Colour: carapace orange brown; with dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae orange; maxillae and labium yellow, distally white; abdomen sepia brown; with dorsally 2 pairs of white patches on anterior part and 1 in front of spinnerets; laterally with 1 white patch; ventrally pale brown; legs yellow; clearly annulated; coxae I-IV white;

trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.62 of headwidth; AME 0.14; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.28; PME-PME 0.28. Clypeus: 0.36mm high.

Male palp (Fig. 12C,D): DTA, PE not reaching tibia; retrolaterally with strong PR; FA short, straight, directed distally; SP not crossing TF; DtiA IP 3 times as long as wide, sharp, EP blunt sticking out; VtiA bird-head-shaped.

Female unknown.

DISTRIBUTION. Known only from Napier Downs (Fig. 19).

KEY TO SPECIES OF *EUASTERON JULIANNAE* GROUP, FEMALES

1. Carapace yellow with dark margin and dark cephalic area; abdomen pale with dark chevrons (Figs 6, 17E,F) . . . . . *E. carnarvon*

   Carapace sepia or orange brown, abdomen sepia brown with 2 or 3 pairs of white spots on anterior part and 1-3 in front of spinnerets, or pale chevrons 2

2. Abdomen with pale chevrons; epigyne, CD extremely long straight (Fig. 17G,H) . . . . . *E. juliannae*

   Abdomen with 2-3 pairs of white spots on anterior part and 3 in front of spinnerets; epigyne, CD long V-shaped (Fig. 17A-D) 3

3. Abdomen with 3 pairs of white spots on anterior part and 3 in front of spinnerets; CO not attached to epigastric fold (Fig. 17A,B) . . . . . *E. johannae*

   Abdomen with 2 pairs of white spots on anterior part and 3 in front of spinnerets; CO attached to epigastric fold (Fig. 17C,D) . . . . . *E. ursulae*

Euasteron johannae sp. nov.
(Figs 14A,B, 17A,B, 20)

ETYMOLOGY. For Johanna Baehr, the author's elder daughter.

MATERIAL. HOLOTYPE: ♂, Barlee Range Nature Reserve, quadrat 5, WA, dry pitfall traps, 23°24'41"S 115°53'39"E, /6/1994, S.van Leeuwen, B.Bromilow (WAM T44458). PARATYPES: WA: ♂,♀, same locality (WAM T51853); 2♂,♀, same locality, quadrat 1, 23°02'39"S 115°48'44"E (WAM T44457); ♂, same locality, quadrat 10, 23°05'45"S, 116°00'35"E (WAM T44460); 18♂,♀, same locality, quadrat 1, 23°02'39"S, 115°48'44"E, /8/1993 (WAM T44453); 5♂,♀, same locality, quadrat 5, 23°24'41"S, 115°53'39"E (WAM T44454); ♂, same locality, quadrat 9, 23°06'06"S, 116°00'28"E (WAM T44455); ♂, same locality, quadrat 12, 23°06'47"S, 116°00'42"E (WAM T44456); 12♂, same locality, site BR5, 23°24'41"S, 115°53'39"E, 11-14 Jun 94, P.G. &, G.W. Kendrick (WAM T44461); 23♂, same locality, site BR9, 23°06'06"S, 16°00'28"E, 19-22 Jun 94 (WAM T44463); ♂, same locality, site BR12, 23°06'47"S, 116°00'42"E (WAM T44464); 2♂,♀, same locality, quadrat 5, 23°24'41"S, 115°53'39"E, /9/1995, S. van Leeuwen, B. Bromilow (WAM T44465); ♂,♀, same locality, quadrat 10, 23°05'45"S 116°00'35"E (WAM T44466); 2♂,♀, same locality, quadrat 11, 23°06'21"S, 115°59'52"E (WAM T44467); ♂, same locality, site BR10, 23°05'45"S, 116°00'35"E, 19/6/1994, P.G &, G.W. Kendrick (WAM T44468); ♂ (palp drawing) same locality, site BR11, 23°06'21"S, 115°59'52"E, 19-22 Jun 94 (WAM T44469).

DIAGNOSIS. Differs from *E. atriceps* and *E. carnarvon* by the sepia brown ceph, from *E. ursulae* and *E. juliannae* by femur I, dark brown, II,IV proximal part white, distal part dark brown and by abdomen with 3 pairs of white patches on anterior part and 3 in front of spinnerets.

DESCRIPTION. *Male* (holotype). Total length 4.12; ceph 2.04 long, 1.44 wide, 0.84 high; cl/ew 1.42; sternum 0.96 long, 0.92 wide; sl/sw 1.04; abdomen 2.08 long, 1.4 wide.

Colour: carapace sepia brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with 3 pairs of white patches on anterior part and 3 in front of spinnerets; legs medium brown, with darker brown lateral stripes; clearly annulated; coxae I-IV white; trochanter I-IV white; femur I dark brown, II-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.65 of headwidth; AME 0.14; ALE 0.1; PME 0.12; PLE 0.12; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.06; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.3; PME-PME 0.3. Clypeus: 0.32mm high.

Male palp (Fig. 14A,B): DTA, PE reaching tibia; retrolaterally with membranous lamella; FA short, rounded; SP broad, S-shaped, crossing TF totally; DtiA IP as long as EP, sharp, EP blunt; VtiA hooked.

Female (paratype). Total length 5.8; ceph 2.28 long, 1.52 wide, 0.84 high; cl/ew 1.5; sternum 1.04 long, 0.96 wide; sl/sw 1.08; abdomen 2.8 long, 2 wide.

Colour: as in male.

Eyes: AME largest; eye group width 0.66 of headwidth; AME 0.14; ALE 0.12; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.04; ALE-PLE 0.08; eyes group AME-PME 0.42; AME-AME 0.3; PME-PME 0.34. Clypeus: 0.4mm high.

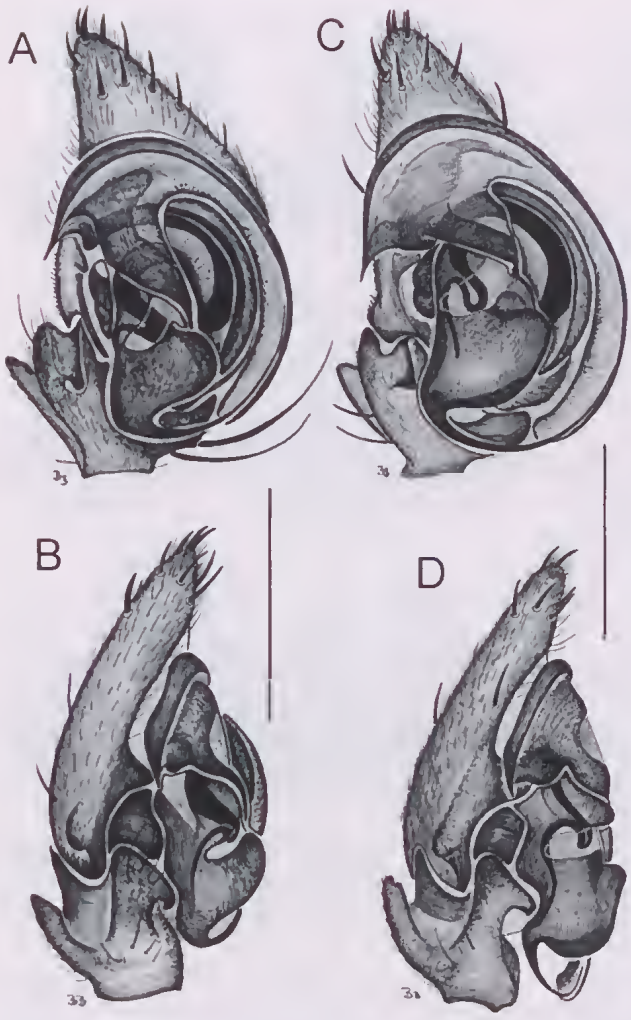

FIG. 14. *Euasteron* spp. right male palps. A,B, *E. johannae*; A, ventral; B, retrolateral; C,D, *E. ursulae*; C, ventral; D, retrolateral. Seale 0.5mm.

Epigyne (Fig. 17A,B): oval CO not attached to epigastric fold, with short, V-shaped sclerotised tubes, CD elongate coiled, axis in V-shaped position. S touching.

DISTRIBUTION. Barlee Range, Western Australia (Fig. 20).

Euasteron ursulae sp. nov.
(Figs 14C,D, 17C,D, 20)

ETYMOLOGY. For Ursula Baehr, the author's younger daughter.

MATERIAL. HOLOTYPE: ♂, Barlee Range Nature Reserve, WA, site BR6, dry pitfall traps 23°23'21"S, 115°53'12"E, 11-14 Jun 94, P.G. & G.W. Kendriek (WAM T44462). PARATYPES: Western Australia: 4♂,♀, Barlee Range Nature Reserve, site BR6, dry pitfall traps 23°23'21"S, 115°53'12"E, 11-14 Jun 94, P.G. & G.W. Kendriek (WAM T52337); 2♂, same locality, (QM S60818); ♂, same locality, quadrat 7, 23°22'45"S, 115°52'50"E, Jun 94, S. van Leeuwen, B. Bromilow (WAM T44459); ♂, same loeality, quadrat 7, 23°22'S 115°52'50"E, /6/1994 (WAM 95/164); 2♂, Cape Range, site TL-1, pitfall traps, 22 15'S, 114 03'E, 16 May-5 June 90, J.M. Waldock (WAM 93/1030-3); ♂, same loeality, site TL-7, 22 15'S, 114 04'E, 20 May-5 June 90 (WAM 93/1073-4); ♂, N-W Cape Penin Site TL-10, 22°08'S, 114°05'E, 21 May-5 June 90, J.M. Waldoek (WAM 93/1087-8); ♂, Cape Range, camp, 22°15'S, 114°03'E, 27 May 90, J.M. Waldoek (WAM 93/1104).

DIAGNOSIS. Differs from *E. atriceps* and *E. carnarvon* by earapaee sepia brown, from *E. johannae* and *E. juliannae* by femur I,II dark brown, III,IV proximal part white, distal part dark brown and by abdomen with 2 pairs of white patehes on anterior part and 3 in front of spinnerets.

DESCRIPTION. *Male* (holotype). Total length 4.84; eeph 2.24 long, I.56 wide, 1 high; el/ew I.43; sternum I.I2 long, 0.96 wide; sl/sw I.I6; abdomen 2.6 long, 1.44 wide.

Colour: earapaee sepia brown; sternum orange brown; eheliceerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with 2 pairs of white patehes on anterior part and 3 in front of spinnerets; legs medium brown, with darker brown lateral stripes; clearly annulated; eoxae I-IV white; troehanter I-IV brown; femur I,II dark brown, III,IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.64 of headwidth; AME 0.I6; ALE 0.I2; PME 0.14; PLE 0.14; AME-AME 0; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.04; AME-AME 0.32; PME-PME 0.32. Clypeus: 0.4mm high.

Male palp (Fig. 14C,D): DTA, PE reaching tibia; retrolaterally with membranous lamella; FA short, rounded; SP S-shaped, narrow, erossing TF totally; DtiA IP as long as EP, sharp, EP blunt; VtiA bird-head-shaped.

Female (paratype). Total length 5.8; ceph 2.6 long, 1.68 wide, 1.04 high; cl/cw 1.54; sternum 1.12 long, 1 wide; sl/sw 1.12; abdomen 3.2 long, 2.2 wide.

Colour: same as males.

Eyes: AME largest; eye group width 0.66 of headwidth; AME 0.16; ALE 0.14; PME 0.15; PLE 0.15; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.04; AME-AME 0.36; PME-PME 0.36. Clypeus: 0.52mm high.

Epigyne (Fig. 17C,D): Oval CO attached to the epigastric fold, with V-shaped sclerotised tubes, CD elongate coiled, axis in V-shaped position. S touching.

DISTRIBUTION. Western Australia (Fig. 20).

Euasteron juliannae sp. nov.
(Figs 13A,B, 17G,H, 20)

ETYMOLOGY. For Ms Julianne Waldock of the Western Australian Museum, the collector of some of the types.

MATERIAL. HOLOTYPE: ♂, Nerren Nerren Station, WA, site NE 4, dry pitfall traps, 27°07'22"S, 114°47'58"E, 15-20 Oct 94, J.M. Waldock et al. (WAM T44500). PARATYPES: Western Australia: ♂, Nerren Nerren Station, site NE 3, wet pitfall traps, 27°07'24"S, 114°46'41"E, 25 Aug-17 Oct 94, J.M. Waldock et al. (WAM T44499); ♂,♀, near Wicherina Dam, vehicle vibration, 28°43'49"S, 115°00'17"E, 2 Nov 98, J.M. Waldock (WAM T44432); ♂,♀, same locality (QM S60815); 6♂, Nanga Station, site NA 2, wet pitfall traps 26°29'23"S, 114°03'21"E, 23 Aug-16 Oct 94, P. West et al. (WAM T44488); 3♂, same locality, dry pitfall traps, 15-20 Oct 94 (WAM ex T44490); ♀, R.G.C. Mine, 10km S of Eneabba, site 3, 29°56'S, 115°17'E, 31 Oct 97, R.P. McMillan, pitfall traps (WAM T44413).

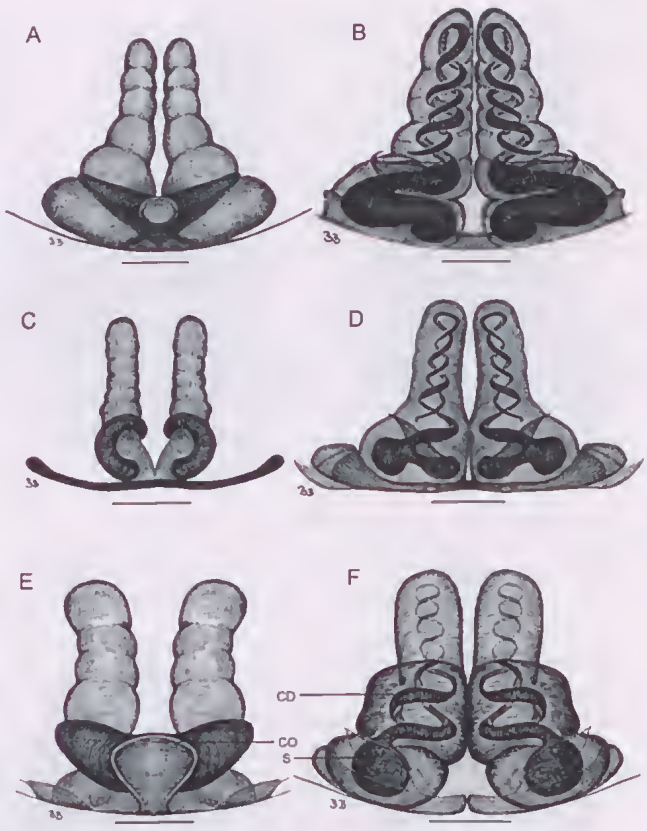

FIG. 15. *Euasteron* spp. epigynes. A,B, *E. enterprise*; A, ventral; B, dorsal (eleared). C,D, *E. monteithorum*; C, ventral; D, dorsal. E,F, *E. milledgei*; E, ventral; F, dorsal. Scales 0.1mm. CO = eopulatory opening; CD = eopulatory duet; S = spermatheca.

DIAGNOSIS. Differs from *E. atriceps* and *E. carnarvon* by sepia brown ceph, from *E. johannae* and *E. ursulae* by proximal part white, distal part dark brown femur I-IV. Abdomen dark with pale chevrons. Palp, SP not crossing transparent field. DTA retrolaterally with lamellae and tiny prong. Epigyne copulatory ducts extremely elongate, coiled about straight axis.

DESCRIPTION. *Male* (holotype). Total length 4.68; ceph 2.36 long, 1.8 wide, 1.04 high; cl/ew 1.31; sternum 1.08 long, 1 wide; sl/sw 1.08; abdomen 2.32 long, 1.68 wide.

Colour: carapace sepia brown; with dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white; abdomen sepia brown; dorsally with pale chevrons; laterally with 1 white patch; legs medium brown, with darker brown lateral stripes; clearly annulated; coxae I-IV white; trochanter I-IV white; femur I-IV proximal part white, distal part dark brown.

Eyes: AME largest; eye group width 0.57 of headwidth; AME 0.16; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.4; AME-AME 0.34; PME-PME 0.34. Clypeus: 0.48mm high.

Male palp (Fig. 13A,B): DTA, PE not reaching tibia; retrolaterally with membranous lamella

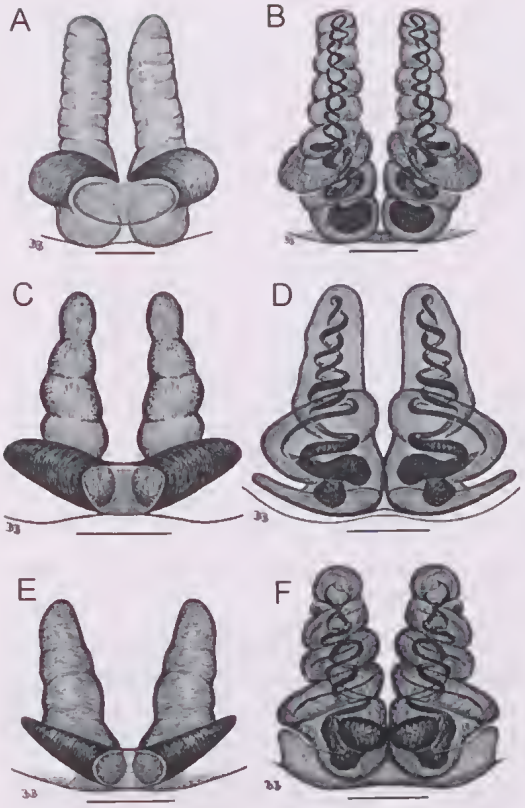

FIG. 16. *Euasteron* spp. epigynes. A,B, *E. willeroo*; A, ventral; B, dorsal (cleared). C,D, *E.bartoni*; C, ventral; D, dorsal. E,F, *E. krebsorum*; E, ventral; F, dorsal. Scales 0.1mm.

and tiny prong; FA short, with rounded tip; SP not crossing TF; tibia short; IP short, EP blunt with incision; VtiA hooked.

Female (paratype). Total length 6.2; ceph 2.6 long, 1.8 wide, 1.04 high; cl/ew 1.44; sternum 1.16 long, 1 wide; sl/sw 1.16; abdomen 3.6 long, 2.2 wide.

Colour: as in males.

Eyes: AME largest; eye group width 0.6 of headwidth; AME 0.16; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.42; AME-AME 0.34; PME-PME 0.34. Clypeus: 0.52mm high.

Epigyne (Fig. 17G,H): Oval CO, attached to epigastric fold U-shaped sclerotised tubes, CD extremely elongate, about 4 × as long as wide, coiled, axis straight. S touching.

DISTRIBUTION. Western Australia (Fig. 20).

Euasteron atriceps sp. nov.
(Figs 13C,D, 20)

ETYMOLOGY. Latin *atriceps* meaning dark-headed; refers to the dark cephalic area.

MATERIAL. HOLOTYPE: ♂, Nerren Nerren Station, WA, site NE2, 27°03'24"S, 114°35'21"E, 25 Aug-16 Oct 94, J.M. Waldock et al., wet pitfall traps (WAM T44495). PARATYPES: Western Australia: 18♂, same as holotype (WAM T52336); 42♂, Nanga Station, site NA4, 26°32'47"S, 113°57'49"E, 16 Oct 94-19 Jan 95, N. McKenzie, J. Rolfe, wet pitfall traps (WAM T44592); 2Y, same locality (QM S60814); 15♂, Nanga Station, site NA5, 26°35'34"S, 113°53'23"E, 16 Oct 94-19 Jan 95, N. McKenzie, J. Rolfe, wet pitfall traps (WAM T44593).

DIAGNOSIS. Differs from *E. johannae*, *E. ursulae* and *E. juliannae* in carapace yellow with dark brown cephalic area, abdomen with dark margin and chevrons on top; from *E. carnarvon* in smaller size and SP not crossing TF.

DESCRIPTION. *Male* (holotype). Total length 3.48; ceph 1.8 long, 1.44 wide, 0.84 high; cl/ew 1.25; sternum 0.84 long, 0.72 wide; sl/sw 1.17; abdomen 1.68 long, 1.16 wide.

Colour: carapace yellow; with dark brown cephalic area, with dark margin and chevrons on top; sternum yellow; chelicerae medium brown; maxillae and labium yellow, distally white; abdomen pale; dorsally with dark chevrons; ventrally mottled with white; legs pale brown; with indistinct colour pattern; coxae I-IV pale; trochanter I-IV pale; femur I-IV pale with brown ring distally; tibia I-IV proximally and distally part with brown spot.

Eyes: AME largest; eye group width 0.62 of headwidth; AME 0.13; ALE 0.1; PME 0.11; PLE 0.12; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.06; ALE-PLE 0.04; eyes group AME-PME 0.3; AME-AME 0.28; PME-PME 0.26. Clypeus: 0.36mm high.

Male palp (Fig. 13C,D): DTA, PE not reaching tibia; retrolaterally with ML; FA wider than long, rounded; SP S-shaped, not crossing TF; DtiA IP as long as EP sharp, EP blunt, VtiA bird-head-shaped.

Female unknown.

DISTRIBUTION. Yamarna Station, WA (Fig. 20).

Euasteron carnarvon sp. nov.
(Figs 6, 13E,F, 17E,F, 20)

ETYMOLOGY. From the type locality. A noun in apposition.

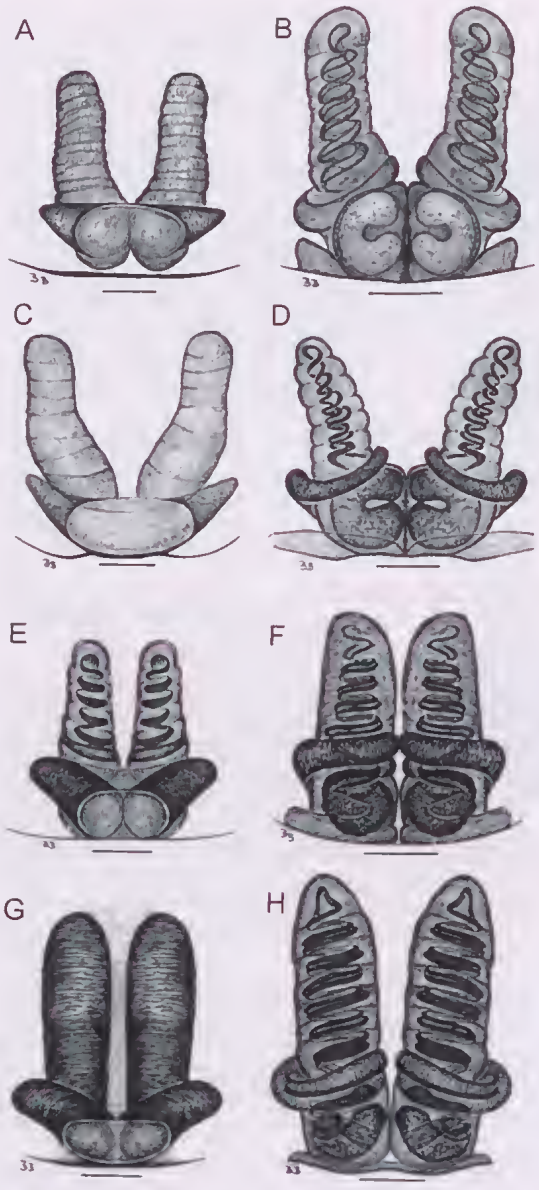

FIG. 17. *Euasteron* spp. epigynes. A,B, *E.johannae*; A, ventral; B, dorsal (cleared). C,D, *E. ursulae*; C, ventral; D, dorsal. E,F, *E. carnarvon*; E, ventral; F, dorsal. G,H, *E. juliannae*; G, ventral; H, dorsal. Scale 0.1mm.

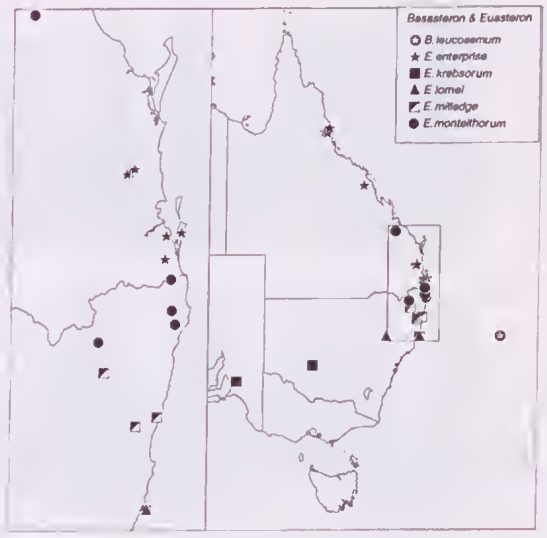

FIG. 18. Records of *Basasteron* and *Euasteron* species in Australia.

MATERIAL. HOLOTYPE: ♂, Nanga Station, WA, site NA 1, dry pitfall traps, 26°28'40"S, 114°04'34"E, 15-20 Oct 94, P. West et al. (WAM T44575). PARATYPES: Western Australia: 2♂,1♀, Nanga Station, site NA 1, dry pitfall traps, 26°28'40"S, 114°04'34"E, 15-20 Oct 94, P. West et al. (WAM T51854); ♂,♀, same locality, site NA1, 11 May-3 Aug 95, N. Hall (QM S60831); ♂, same locality, site NA 5, 26°35'34"S, 113°53'23"E, P. West et al. (WAM T44577); ♂, Zuytdorp, site ZU 1 wet pitfall traps, 27°15'42"S, 114°01'09"E, 26 Aug-15 Oct 94, A. Sampey et al. (WAM T44511); 2♂, Zuytdorp, site ZU 1, wet pitfall traps, 27°15'42"S, 114°01'09"E, 15 Oct 94-11 Jan 95, N. McKenzie, J. Rolfe (WAM T44512); 2♂, Zuytdorp, site ZU 2, wet pitfall traps, 27°15'41"S, 114°01'48"E, 26 Aug-15 Oct 94, A. Sampey et al. (WAM T44514); 2♂, same locality, 15 Oct 94-11 Jan 95, N. McKenzie, J. Rolfe (WAM T44515); ♂, same locality, site ZU 3, 27°15'34"S, 114°04'03"E, 26 Aug-17 Oct 94, A. Sampey et al. (WAM T44518); ♂, same locality, site ZU 4, dry pitfall traps, 27°15'28"S, 114°09'02"E, 14-19 Oct 94, A. Sampey et al. (WAM T44520); ♂,♀, Barlee Range Nature Reserve, quadrat 2, wet pitfall traps, 23°03'41"S, 115°47'15"E, Jun 94, S. van Leeuwen, B. Bromilo (QM S60831).

DIAGNOSIS. Differs from *E. johannae*, *E. ursulae* and *E. juliannae* in carapace yellow, dark brown cephalic area and dark margin and chevrons on top. From *E. atriceps* in bigger size and SP partly crossing TF.

DESCRIPTION. *Male* (holotype). Total length 4.04; ceph 2.12 long, 1.64 wide, 0.92 high; cl/cw 1.29; sternum 1 long, 0.96 wide; sl/sw 1.04; abdomen 1.92 long, 1.4 wide.

Colour: carapace yellow; with dark brown cephalic area, with dark margin and chevrons on top; sternum yellow; chelicerae medium brown; maxillae; labium yellow, distally white; abdomen pale; dorsally with dark chevrons; ventrally mottled with white; legs pale brown; with

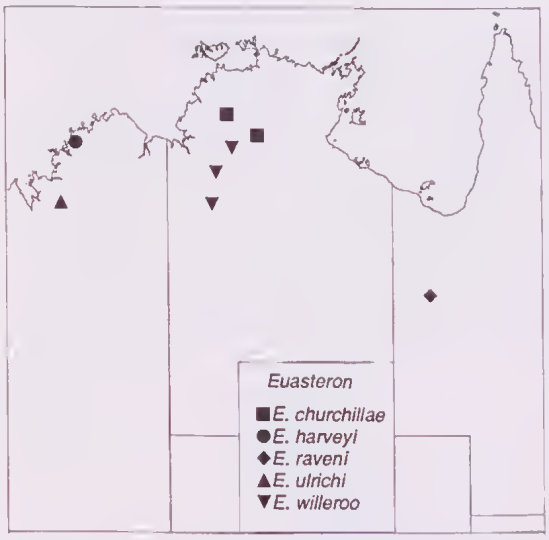

FIG. 19. Records of *Euasteron* species in Australia.

indistinct colour pattern; coxae I-IV pale; trochanter I-IV pale; femur I-IV pale with brown ring distally; tibia I-IV proximally and distally with brown spot.

Eyes: AME largest; eye group width 0.62 of headwidth; AME 0.15; ALE 0.12; PME 0.13; PLE 0.13; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.32; PME-PME 0.32. Clypeus: 0.4mm high.

Male palp (Fig. 13E,F): DTA, PE not reaching tibia; retrolaterally with ML and short prong; FA short, rounded tip; SP S-shaped, partly crossing TF; tibia short; DtiA IP as long as EP, tapered, EP blunt, pale brown; VtiA bird-head-shaped.

Female (paratype). Total length 4.04; ceph 2.12 long, 1.64 wide, 0.92 high; cl/ew 1.29; sternum 1 long, 0.96 wide; sl/sw 1.04; abdomen 1.92 long, 1.4 wide.

Colour: as in males.

Eyes: AME largest; eye group width 0.62 of headwidth; AME 0.15; ALE 0.12; PME 0.13; PLE 0.13; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.32; PME-PME 0.32. Clypeus: 0.4mm high.

Epigyne (Fig. 17E,F): Oval CO attached to the epigastric fold, with U-shaped sclerotised tubes, CD elongate 3 times as long as wide, coiled, axis more or less straight. S touching.

DISTRIBUTION. Western Australia (Fig. 20).

DISCUSSION

The *Asteron*-complex now contains 11 genera with 57 species. *Asteron* originally included only *A. reticulatum* and *A. mas* Joequé, 1991. However, *A. mas* is still not correctly placed in any of the described genera. The first overview of *Euasteron* indicated that *A. mas* should be a member of this genus. A more careful examination showed that *A. mas* is more derived in palpal structure and in the epigyne than any *Euasteron* species.

In *Basasteron*, *Euasteron* and *Spinasteron*, the abdominal pattern is an excellent character to separate species if the spiders are well preserved. The most common pattern is a dark abdomen with 2-5 pairs of white patches on top, and 1-3 in front of spinnerets. It occurs also in all other described genera in the *Asteron*-complex as well as in *Habronestes* and *Storena* (Joequé & Baehr, 1992).

As in *Habronestes*, the relative size of AME is a very stable character to separate species-groups in *Euasteron*. Using the eye pattern, *Euasteron* can be divided into the *E. enterprise*-group (7 species) the AME are the smallest; *E. willeroo* has equal-sized eyes; and the *E. juliannae*-group (7 species) have AME the largest.

Nevertheless, the definition of genera in Australian zodariids has been mainly based on genital characters (Baehr & Joequé, 1996, 2000, 2001; Joequé & Baehr, 2001).

During this work it became obvious that the retrolateral structure of the cymbium is a good synapomorphic character to separate taxa of the *Asteron*-complex.

Basasteron shares the straight retrolateral cymbial flange with (Fig. 3B) with more basic *Pentasteron*, *Phenasteron* and *Leptasteron*. But the general bulb structure of *Basasteron* — a circular shape of the DTA and the shape of the embolus — is basically the same as in *Cavasteron*, *Minasteron*, *Euasteron* and *Spinasteron*. Whereas in *Basasteron*, the embolus originates prolaterally, in *Cavasteron*, *Minasteron*, *Euasteron* and *Spinasteron*, the origin is basal.

The special type of tibial apophysis — with 2 apophyses forming a deep concavity in between, dorsal one divided in two parts, the internal prong (IP) and the external prong (EP) connected by a ridge; ventro-lateral tibial apophysis hooked or bird-head-shaped — is obviously a synapomorphy of *Cavasteron*, *Euasteron*, *Minasteron* and

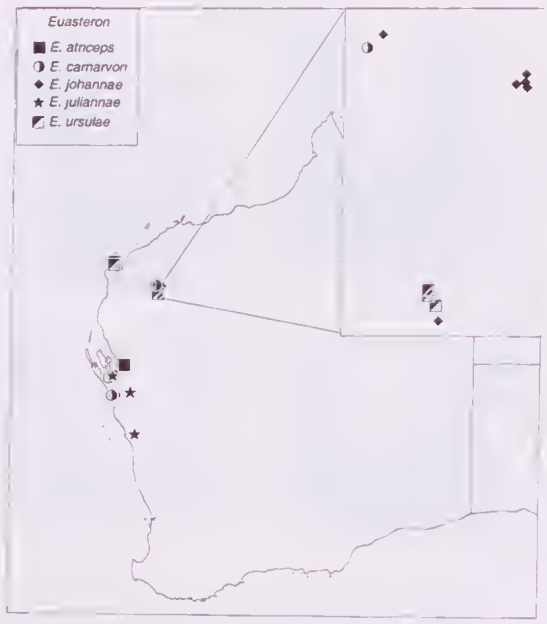

FIG. 20. Records of *Euasteron* species in Western Australia.

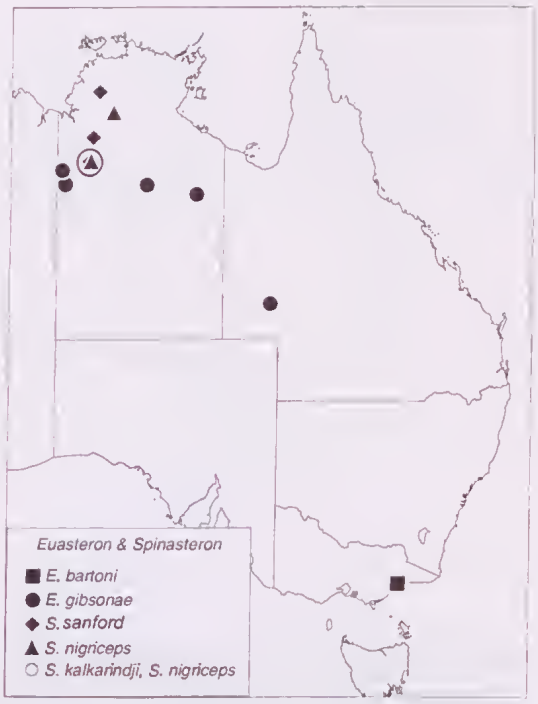

FIG. 21. Records of *Spinasteron* and *Euasteron* species in Australia.

Spinasteron. It is not developed in *Basasteron*, which has only 2 small apophyses and a beginning of a ridge. All these preliminary data indicate that *Basasteron* is the sister genus of *Cavasteron*, *Euasteron*, *Minasteron*, and *Spinasteron*.

Euasteron can be easily separated from *Cavasteron* and *Minasteron* by the lack of a large terminal claw in male palps and by the more elongate and curled copulatory ducts in the epigynes.

Spinasteron shares the special tibial apophysis structures and the special bulb characters with *Cavasteron*, *Euasteron* and *Minasteron*. The barely developed retrolateral cymbial flange with only a tiny knob seems to be a reduction of the flange with a well-developed rounded extension (RE) (Fig. 4B,C) occurring in *Cavasteron*, *Euasteron*, *Minasteron*. *Spinasteron* could be a more derived sister genus to *Euasteron*. *Spinasteron* is not fully revised yet. All these species have very complicated palps.

ACKNOWLEDGEMENTS

I thank Tracey Churchill (formerly of the C.S.I.R.O.), Michael Gray, Graham Milledge, Australian Museum (Sydney), Mark Harvey, Julianne Waldock, Western Australian Museum (Perth), David Hirst, South Australian Museum (Adelaide) and Robert Raven, Queensland Museum (Brisbane) for loan of the material and support of the work. The following people of the Northern Territory I would like to thank for providing access to research sites: Dave Moller, Manager of Willeroo Station; Don Cherry, Manager of Kidman Springs Station; Paul Stone, Manager of Mount Sanford Station, Heytesbury Pastoral. For an excellent working atmosphere I thank Valerie Davies, for being patient, my children Johanna and Ursula Baehr, and for preparing the maps and assisting with the SEM Robert Raven.

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BLASTOBASINE COLEOPHORID MOTHS AS PREY FOR THE AUSTRALIAN ARANEID SPIDER *CELAENIA CALOTOIDES* RAINBOW. *Memoirs of the Queensland Museum 49(1): 28. 2003:-* The Australasian araneid *Celaenia* Thorell, and species of *Ordgarius* Keyserling, *Cladomelea* Simon and *Mastophora* Holmberg ('bolas' spiders), have unique life-history strategies. As older juvenile and adult females, all are thought to be obligate predators of Lepidoptera, using complex chemical mimicry of female sex pheromones to attract male moths of only a few species (Eberhard, 1977; Stowe et al., 1987; Yeargan, 1988, 1994; Haynes et al., 1996). Young juveniles and males of some taxa also attract male nematoceran Diptera (Eberhard, 1980; Yeargan & Quate, 1996, 1997). Stowe et al. (1987) showed that 3 molecules released by *M. cornigera* (Hentz) ([Z]-9-tetradecenyl, [Z]-9-tetradecenal & [Z]-11-hexadecenal) are identical to sex pheromone components of some prey moth species. Gemeno et al. (2000) showed that *M. hutchinsoni* Gertsch females produce an allomone blend that mimics, in both composition and blend ratio, the sex pheromone of the noctuid moth *Lacinipolia renigera* (Stephens). Web reduction is characteristic of this group with a single line of sticky silk used to capture flying moths. In *Celaenia* no web snare is made, and moths are grasped directly with the enlarged, spined legs I and II (pers. obs.).

Of 11 species of *Celaenia* (7 from Australia), few specific prey records are available (Table 1). Notes on *C. kinbergi* are listed under *C. excavata* L. Koch, the senior synonym. Roberts (1937) collected several moths dropped by a female *C. excavata*, and suggested 'olfactory attraction' may be involved, but did not identify any taxa. Mascord (1980) reported that a female of *C. excavata* captured 43 male moths 'of one species' in one month.

Observations of two juvenile and one adult female *C. calotoides* Rainbow, 1908 were maintained over five weeks during the Spring of 2002, in Brisbane. Cardboard trays and paper bags were set up as receptacles under the spiders to catch dropped prey items. The female (5mm long; with egg sacs) was observed for 39 days (5 Oct.-13 Nov.). Similarly, an older juvenile (2.5mm long) was observed for 30 days (14 Oct.-13 Nov.) along with a small juvenile (1.5mm long, after having hatched out of the female's first egg sac on 20 Oct.), the latter observed for 12 days between November 1-13. All specimens were observed as they were found, in-situ in a suburban garden (27°30'53"S 153°04'06"E).

After laying its third egg sac on 7-8 Oct., the adult female *C. calotoides* captured three male *Blastobasis* Zeller (Gelechioidea, Coleophoridae, Blastobasinae) (Table 2). The larger juvenile spider captured four *Blastobasis* moths during the study period. The small newly-hatched juvenile spider caught one moth during the study period, and this too was a *Blastobasis* species. All specimens appear to be conspecific (although the genitalia of some were damaged by the spiders whilst feeding), and further observations of moths attracted to house lights in the area revealed the presence of a single, very common species (based on the uniform morphology of the males' genitalia). These data provide the first evidence of a gelechioid moth being targeted by a species of *Celaenia*, and the first record of a newly-hatched juvenile feeding on a lepidopteran (as opposed to a dipteran) after emergence from the egg sac.

Moths referred to herein are lodged at the Queensland Museum, with the adult female *C. calotoides* (QM S60739).

TABLE 1. Published prey records for spiders in *Celaenia*.

Spider	Loc.	Prey	Reference
Adult ♀ *C. excavata*	Qld, Aus.	*Spodoptera mauritia* (Lepidoptera, Noctuoidea, Noctuidae, Amphipyrinae)	Zillman, 1988
Adult ♀ *Celaenia* sp.	NZ	'Tortrix moths' (Lepidoptera, Tortricoidea, Tortricidae)	Forster & Forster, 1999
Juvenile *Celaenia* sp.	NZ	'Moth flies' (Diptera, Nematocera, Psychodoidea, Psychodidae)	Forster & Forster, 1999
Adult ♀ *C. distincta*	Tas., Aus.	'Night-flying moths'	Hickman, 1970
Adult ♀ *C. atkinsoni*	Tas., Aus.	'Small moths'	Hickman, 1970

TABLE 2. Moth prey (*Blastobasis* sp.) records for adult and juvenile *C. calotoides* in Brisbane. Length is taken longitudinally from head to wing tips, after specimens had been wrapped with silk by spiders.

Prey moth ref.	Spider	Length	Date captured
A1	♂ adult	8.5mm	11-12/10/02
A2	♂ adult	7.0mm	9-10/11/02
A3	♂ adult	7.5mm	12-13/11/02
J1	♂ older juvenile	5.5mm	22/10/02
J2	♂ older juvenile	5.5mm	24/10/02
J3	♂ older juvenile	5.0mm	1-2/11/02
J4	♂ older juvenile	6.5mm	5/11/02
B1	♂ small juvenile	6.0mm	11/11/02

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TROPASTERON GEN. NOV. OF THE *ASTERON*-COMPLEX (ARANEAE: ZODARIIDAE) FROM TROPICAL QUEENSLAND

BARBARA BAEHR

Baehr, B. 2003 06 30: *Tropasteron* gen. nov. of the *Asteron*-complex (Araneae: Zodariidae) from tropical Queensland. *Memoirs of the Queensland Museum* 49(1): 29-64. Brisbane. ISSN 0079-8835.

Tropasteron contains 22 new species of the *Asteron*-complex, a large group of endemic Australian Zodariidae. *Tropasteron* consists of two species-groups which are distinguished by their size, slightly different palps and epigynes, and their different abdominal colour pattern. The *T. cleveland*-group with 18 species includes the type species *Tropasteron cleveland* sp. nov. (♂,♀) and *T. cardwell* sp. nov. (♂,♀), *T. cooki* sp. nov. (♂,♀), *T. daviesae* sp. nov. (♂,♀), *T. eacham* sp. nov. (♂,♀), *T. fox* sp. nov. (♂,♀), *T. halifax* sp. nov. (♂,♀), *T. heatherae* sp. nov. (♂,♀), *T. julatten* sp. nov. (♂,♀), *T. luteipes* sp. nov. (♂,♀), *T. malbon* sp. nov. (♂,♀), *T. monteithi* sp. nov. (♂,♀), *T. palmerston* sp. nov. (♂), *T. raveni* sp. nov. (♂,♀), *T. splendens* sp. nov. (♂), *T. thompsoni* sp. nov. (♂,♀), *T. tribulation* sp. nov. (♂,♀), *T. yeatesi* sp. nov. (♂,♀). The larger and much more rare species of the *Tropasteron andreae*-group are represented by *Tropasteron andreae* sp. nov. (♂,♀), *T. magnum* sp. nov. (♂), *T. pseudomagnum* sp. nov. (♂) and *T. robertsi* sp. nov. (♂). All species are found only in the tropical rainforests of Queensland. ❐ *Spiders, rainforest, Zodariidae, Tropasteron.*

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This is the fifth systematic paper on the *Asteron*-complex (Baehr & Jocqué, 1996) of zodariid spiders, that now contains 12 genera with 79 species.

Like the rest of the *Asteron*-complex (Baehr, in press; Baehr & Jocqué, 2000, 2001; Jocqué & Baehr 2001) *Tropasteron* is endemic to Australia and occurs almost exclusively in the rainforest mountain systems of north Queensland. Most of the 766 specimens were collected in wet tropic surveys undertaken by G. Monteith, V. Davies, R. Raven and other Queensland Museum staff, to examine the broad patterns of species geography across the area (Monteith, 1995). Target taxa were insects with low vagility, e.g. Scarabaeidae (Reid & Storey, 2000; Storey & Monteith, 2000), Tenebrionidae (Bouchard, 2002), wingless Carabidae (Baehr, 1995) and Aradidae (Monteith, 1997). In addition to the mygalomorph spiders (e.g. Raven 1979, 2000) and some araneomorph spider groups of Amphinectidae and Kababinae (e.g. Davies, 1995, 1999, 2000a, 2000b), *Tropasteron* becomes the sixth Wet Tropics spider group to be used for low vagility studies.

Tropasteron gen. nov., mentioned in Baehr & Jocqué (1996) as *Asteron queenslandicum*-group, can be easily separated from all other genera by a number of synapomorphies mentioned in the genus description.

MATERIAL AND METHODS

Descriptions are generated with the aid of DELTA and Intkey (Dallwitz et al., 1998) and shortened where possible.

Drawings were done from body, right palp, epigyne and vulva. All measurements are in mm.

Spination and colour patterns are dealt with as in the revision of *Euasteron* (Baehr, this volume).

Divisions of the Wet Tropics used in the discussion of distribution are the Rainforest Mountain Blocks proposed by Monteith (1995) and modified in Bouchard (2002).

Abbreviations of characters: ALE, anterior lateral eyes; AME, anterior median eyes; AS, anterior spinnerets; CD, copulatory duct; CE, rounded extension on cymbium; Ceph, cephalothorax; CO, copulatory opening; CR, chitinous rim; DTA, dorsal tegular apophysis; DtiA, dorsolateral tibial apophysis; E, embolus; EP, external prong on dorso-retrolateral tibial apophysis; F, flange on cymbium; Fe, femur; IP, internal prong on dorso-retrolateral tibial apophysis; MS, median spinnerets; MEG, median eye group; MT, metatarsus; P, patella; PE, prolateral extension of DTA; PLE, posterior lateral eyes; PME, posterior median eyes; PS, posterior spinnerets; S, spermatheca; sl/sw, sternum length/width; SP, sperm duct; T, tibia; Ta, tarsus; TF, transparent field on embolus base; VtiA, ventral tibial apophysis.

Abbreviations of institutions where material is deposited: AM, Australian Museum, Sydney (M. Gray); QM, Queensland Museum, Brisbane (R. Raven).

Abbreviations of common collector names: DC, D.J. Cook; DY, D. Yeates; GM, G.B. Monteith; GT, G.I. Thompson; HJ, H. Janetzki; JG, J. Gallon; MS, M. Shaw; RR, R.J. Raven; PL, P. Lawless; SH, S. Hamlet; VD, V. Davies.

SYSTEMATICS

KEY TO SPECIES GROUPS OF *TROPASTERON*

1. Clypeus at least 5.5 times diameter of ALE high. Palp, (EP) distally flattened, cymbial flange short straight, with distal hook, only about 10% of cymbium long, epigyne CO lyriform (Fig. 6G-J) . . . *T. andreae*-group

   Clypeus less than 5 × diameter of ALE high. Palp, (EP) with sharp tip, cymbial flange straight, without distal hook, about 15% of cymbium long, epigyne CO semicircular or oval (Figs 5A-L, 6A-F) . . *T. cleveland*-group

KEY TO SPECIES OF *T. CLEVELAND*-GROUP

Males

1. Palp without LTA spine (Figs 9B) 2

   Palp with LTA spine (Fig. 1C) 3

2. Palp, DtiA, EP short, about as long as wide at base; abdomen with 3 pairs of big white patches dorsally (Fig. 5D, 9A-F). . . . . *T. daviesae*

   Palp, DtiA, EP long, EP at least twice as long as wide at base; abdominal pattern not as above (Fig. 6A; 18A-D) . . . . . *T. palmerston*

3. Abdomen frontally without any white or pale spots (Fig. 1A) 4

   Abdomen frontally with pairs of white spots (Fig. 22C) . 10

4. Palp DtiA, EP short, about as long as wide at base (Fig. 5A,D,F, 6B) 5

   Palp DtiA, EP long, EP at least twice as long as wide at base (Fig. 5B,C,E,G-L) 7

5. Palp, with short LTA spine, about as long as wide; sperm duct semicircular; abdomen with 2 pairs of white dots dorsally (Fig. 19A-D) . . . . . *T. raveni*

   Palp, with long LTA spine, at least 3 times as long as wide; sperm duct inverted U-shaped (Fig. 1C, 11B) 6

6. Abdomen with 2 pairs of white dots dorsally, second pair forming a transverse stripe (Fig. 11A-D) . . . . . *T. fox*

   Abdomen with 2 pairs of white dots dorsally, without transverse stripe (Fig. 1A-C). . . . . *T. cleveland*

7. Abdomen ventrally without any colour pattern, dorsally with 2 pairs of white dots (Fig. 12A-D) . . . . *T. halifax*

   Abdomen ventrally otherwise (Figs 8D, 17D, 23D, F) . 8

8. Abdomen ventrally with 1 pair of white stripes (Fig. 17A-D) . . . . . *T. monteithi*

   Abdomen ventrally with white chevrons (Fig. 1A-C) . 9

9. Abdomen with light patches arranged as in Fig. 8C, D . . . . . *T. cooki*

   Abdomen with light patches arranged as in Fig. 23C-F . . . . . *T. yeatesi*

10. Abdomen frontally with 1 additional pair of fronto-lateral white spots (Fig. 23C-F) 11

    Abdomen frontally without additional pair of fronto-lateral white spots (Fig. 21C-D) 14

11. Palp, with short LTA spine (Fig. 14B) . . . . *T. julatten*

    Palp, with long LTA spine, at least 3 × as long as wide (Fig. 10B, 15B, 21B). 12

12. Abdomen frontally with 1 pair of white spots additional to 1 fronto-lateral pair (Fig. 21A-D) . . . . . *T. thompsoni*

    Abdomen frontally with more than 1 pair of white spots additional to 1 fronto-lateral pair (Figs 10C, 15C) . . 13

13. Abdomen frontally with 2 pairs of white spots additional to 1 fronto-lateral pair (Fig. 10C) . . . . . *T. eacham*

    Abdomen frontally with 3 pair of white spots additional to 1 fronto-lateral pair (Fig. 15C) . . . . . *T. luteipes*

14. Palp with short LTA spine (Fig. 16B) . . . . . *T. malbon*

    Palp with long LTA spine, at least 3 times longer than wide (Figs 7B, 13B, 20B, 22B). 15

15. Abdomen frontally with 1 pair of white spots (Fig. 7A-D) . . . . . *T. cardwell*

    Abdomen frontally with more than 1 pair of white spots (Figs 13C, 12C, 22C) 16

16. Abdomen frontally with 3 pairs of white spots (Fig. 22A) . . . . . *T. tribulation*

    Abdomen frontally with 2 pairs of white spots (Figs 20C, 13C) 17

17. Abdomen dorsally with 2 pairs of white spots and 2 in front of spinnerets, additional to frontal spots (Fig. 20A-D) . . . . . *T. splendens*

    Abdomen frontally with 4 pairs of white spots, dorsally with 2 pairs and 2 in front of spinnerets, additional to frontal spots (Fig. 13A-D) . . . . . *T. heatherae*

Females

1. Abdomen frontally without any white spots (Fig. 1A) . 2

   Abdomen frontally with pairs of white spots (Fig. 22C) . 9

2. Abdomen dorsally with 2 pairs of white dots (Fig. 1A) . 3

   Abdomen dorsally otherwise. 5

3. Femur I dark brown, II-IV proximal part white, distal part brown epigyne (Fig. 3B,C). . . . . *T. cleveland*

   Femur I-IV same colour pattern 4

4. Femur I-IV proximal margin brown, medium part white, distal part brown, epigyne longer than wide, CO semicircular (Fig. 19C-G). . . . . *T. raveni*

   Femur I-IV proximal part white, distal part brown, epigyne wider than long, CO oval (Fig. 12C-G) . . . . *T. halifax*

5. Abdomen ventrally without any colour pattern, epigyne, CO flattened oval (Fig. 11C-F) . . . . . *T. fox*

   Abdomen ventrally with colour pattern 6

6. Abdomen ventrally with 1 pair of white stripes; epigyne (Fig. 17C-F) . . . . . *T. monteithi*

   Abdomen ventrally with chevrons (Figs 8D, 9D, 23D, F) . 7

7. Legs pale without colour pattern, small about 3.5mm; epigyne (Fig. 9C-F). . . . . *T. daviesae*

   Legs with indistinct colour pattern or clearly annulated . 8

8. Abdomen laterally with 1 long white stripe, epigyne CO flat oval (Fig. 23C-H). . . . . *T. yeatesi*

   Abdomen laterally with white chevrons, epigyne CO semicircular (Fig. 8C-F) . . . . . *T. cooki*

9. Abdomen frontal with 1 additional pair of fronto-lateral white spots (Figs 10C, 14C, 15C, 21C). 10

Abdomen frontal without fronto-lateral white spots (Figs 7C, 13C, 16C, 22C) 13

10. Abdomen ventrally without any colour pattern (Figs 14D, 15D) 11

Abdomen ventrally with white stripes or patches (Fig. 21D) 12

11. Abdomen frontally with 2 pairs of small white spots, epigyne as in Fig. 14C-F . . . . . *T. julatten*

Abdomen frontally with 3 pairs of small white spots, epigyne as in Fig. 15C-F . . . . . *T. luteipes*

12. Abdomen ventrally with 3 white stripes, epigyne as in Fig. 21C-F . . . . . *T. thompsoni*

Abdomen ventrally with 1 pair of white patches near tracheal spiracle, epigyne as in Fig. 10C-E . . *T. eacham*

13. Abdomen frontally with 1 pair of small white spots (Figs 7C-F, 16C-F) 14

Abdomen frontally with 2-3 pairs of small white spots, epigyne as in Figs 13C-F, 22C-F 15

14. Epigyne, CO semicircular (Fig. 16C-F) . . . . *T. malbon*

Epigyne, CO flattened oval (Fig. 7C-F) . . . *T. cardwell*

15. Abdomen frontally with 2 pairs of small white spots, epigyne (Fig. 13C-F) . . . . . *T. heatherae*

Abdomen frontally with 3 pairs of small white spots, epigyne (Fig. 22C-F) . . . . . *T. tribulation*

Tropasteron gen. nov.

TYPE SPECIES. *Tropasteron cleveland* sp. nov.

ETYMOLOGY. Occurs only in tropical eastern Queensland, from Iron Range (12°40'S) to Carmila (21°52'S).

DIAGNOSIS. *Tropasteron* gen. nov., mentioned in Baehr & Joequé (1996) as *Asteron queenslandicum*-group, can be easily separated from all other genera by the synapomorphies:

1) the very short, straight cymbial flange, with only 10-15% length of cymbium and the small rounded extension CE (Fig. 1B);

2) the long spine-like LTA (Fig. 3C), the more or less cylindrical base of the embolus (Fig. 3B);

3) the prolateral extension (PE) of semicircular, distally-folded, dorsal tegular apophysis (DTA), short not longer than base of DTA (Fig. 3B);

4) the ventro-lateral tibial apophysis with chitinous rim (CR) (Fig. 1B);

5) the bifurcate dorsolateral palpal tibial apophysis, internal prong (IP) about 1/3 of external prong (EP) (Figs 5A-L, 6A-J);

6) the more or less square epigyne with semicircular to flat oval copulatory opening (CO), not attached to the epigastric fold, copulatory duct (CD) elongate with big semicircular distal loop, curled and ending in not touching spermatheeae (S) (Fig. 2B,C);

7) the strong female palpal claw with more than 6 teeth (Fig. 4B).

Although *Tropasteron* is well separated by these synapomorphies, all species are similar in their palpal and epigynal structure. Therefore, unfortunately, the abdominal and leg colour pattern are often the only characters to easily separate species.

DESCRIPTION. Medium-sized spiders (3.00-7.50) with finely reticulate tegument. Carapace widest at coxae II. Profile flat with highest point between fovea and PME (Fig. 1A,D).

Colour: carapace, sternum yellow to sepia brown; chelicerae yellow to medium brown; maxillae and labium yellow to medium brown, distally white; abdomen dorsally sepia brown with or without weak scutum with 2-4 pairs of white patches on anterior part and 1-3 in front of spinnerets; frontally with or without 1-3 pairs of small white spots, frontolaterally with or without 1 pair of small white spots; laterally with 2-4 white stripes or mottled with white; ventrally paler brown to dark brown, mottled with white; with or without with 1 pair of elongate white stripes and or 1 white stripe from epigastric fold to near tracheal spiracle, legs yellow, pale to medium brown, indistinct or clearly annulated.

Carapace: broadly oval, finely reticulated.

Sternum: shining; heart-shaped anteriorly straight; with short and longer setae.

Eyes (Fig. 1A,D,E): in 3 rows (2-4-2). AME smallest; eye group width 0.46-0.69 of headwidth. MEG slightly longer than wide. Clypeus straight, about 5.5-6 times (*T. andreae*-group) and 3-4.4 times (*T. cleveland*-group) diameter of ALE high. Chilum single or divided. Chelicerae as usual for family with few hairs in front and dense row on distal promargin; no teeth. Maxillae and labium triangular; sparsely haired; maxillae with anteromesal scopula. Sternum flat; heart-shaped with straight anterior margin, shining; with long setae around margin.

Mouthparts: chelicerae, basal segment laterally with condyle; maxillae triangular, with promarginal scopula; labium triangular.

Abdomen: PLS small; widely spaced with PMS in one row; PMS tiny; colulus only some hairs; tracheal spiracle small slit-like, with a tiny pit (Fig. 3A).

Legs: Formula 4123. Spination: few spines on pairs I, II, more numerous on III, IV. Paired tarsal claws with numerous (±14) teeth on inner side of claw. Unpaired claw toothless, on very small onychium. Metatarsal preening brush on Mt II and III poorly developed.

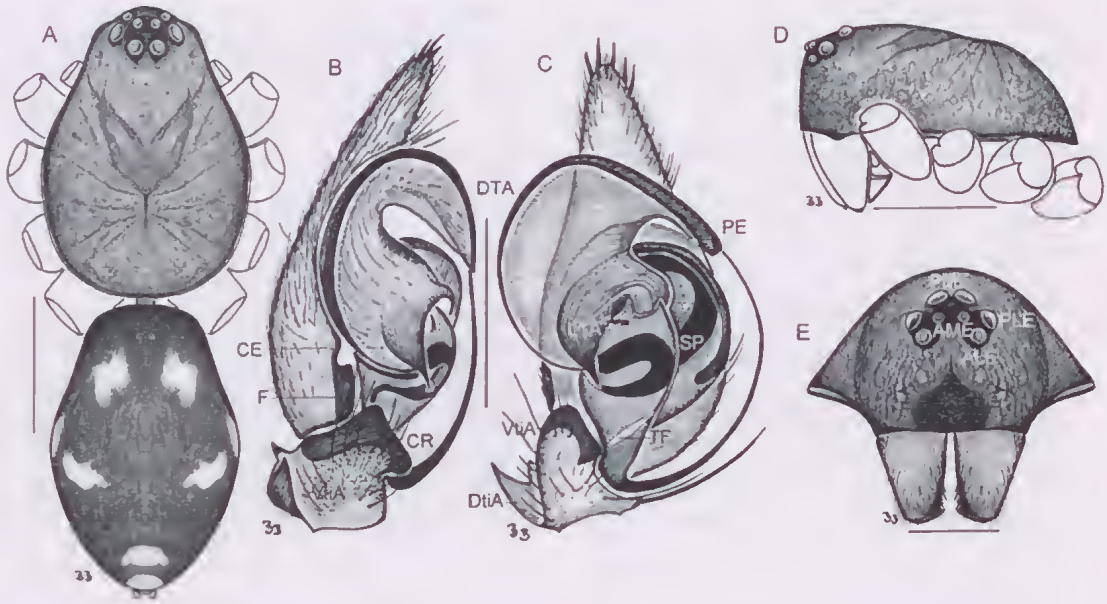

FIG. 1. *Tropasteron cleveland* male. A, body dorsal; B,C, plap; B, lateral, C, ventral, scale 0.5mm; D,E, cephalothorax; D, lateral; E, frontal, scale 1mm. ALE = anterior lateral eyes, AME = anterior median eyes, CE = rounded extension on eymbium, CH = hook on eymbial flange, CR = chitinous rim, DTA = dorsal tegular apophysis, DtiA = dorsolateral tibial apopysis, E = embolus, F = flange on eymbium, LTA = lateral tegular apopysis (spine), MEG = median eye group, PE = prolateral extension of DTA, PLE = posterior lateral eyes, PME = posterior median eyes, SP = sperm duct, TF = transparent field on embolus base, VtiA = ventral tibial apophysis.

Male palp (Fig. 1B,C): tibia short with dorsolateral and ventrolateral apophysis. Dorsolateral tibial apophysis bifid with sharp internal (IP) and external prong (EP). In *T. andreae*-group EP distally flattened. Cymbial flange short straight, only 10-15% of eymbium long, distally followed by small rounded extension, incision in between.

DTA, semicircular, distally folded with short PE, not longer then base of DTA; retrolaterally with retrolaterally with sharp tip and without any additional extension; sperm duct inverted U-shaped; embolus thin, semicircular, embolus base cylindrical; tibia short; ventrolateral tibial apophysis with chitinous rim dorsally, connected with dorsolateral apophysis. Femur with 2 strong spines dorsally. Embolus semicircular conducted by DTA.

Females are often bigger than males but body shape and colour pattern are the same. In contrast the female ceph is higher and clypeus is bowed, visible from dorsal view (Fig. 2A,D,E). Epigynes (Fig. 2B, C) of all *Tropasteron* species are very similar: all are as long as wide, with semicircular oval or lyriform CO, not attached to the epigastric fold, CD elongate with big semicircular distal loop, curled and ending in not touching S.

Tropasteron cleveland sp. nov.
(Figs 1, 2, 3, 4, 5A, 29)

ETYMOLOGY. The species name is taken from the type locality. A noun in apposition.

MATERIAL. HOLOTYPE: ♂, Mt Cleveland, NE Qld, 500m, blady grass, open forest, 19°15'23"S, 147°01'40"E, 22 Jan-21 Mar 1991, A. Graham, pitfall (QM S17982). PARATYPES: NE Qld: 11f, 19m, same data as holotype (QM S57097); 2m, same locality, 20 Jan-12 Mar 1991 (QM S17972); 1f, as previous, 19°16'S, 147°03'E, Jan-12 Mar 1991 (QM S46780); 1m, as previous, summit, 560m, open forest, 19°15'23"S, 147°01'40"E, 22-24 Mar 1991, GM, DC (QM S17928); 2f, 6m, as previous, 500m, rainforest, 19°15'23"S, 147°01'40"E, 20 Jan-12 Mar 1991, A. Graham (QM S17902).

DIAGNOSIS. Differs from most other species by short EP (Fig. 5D). Similar to *T. raveni* in the abdomen lacking white spots frontally, but differs by femur I dark brown, II-IV proximal part white, distal part dark brown.

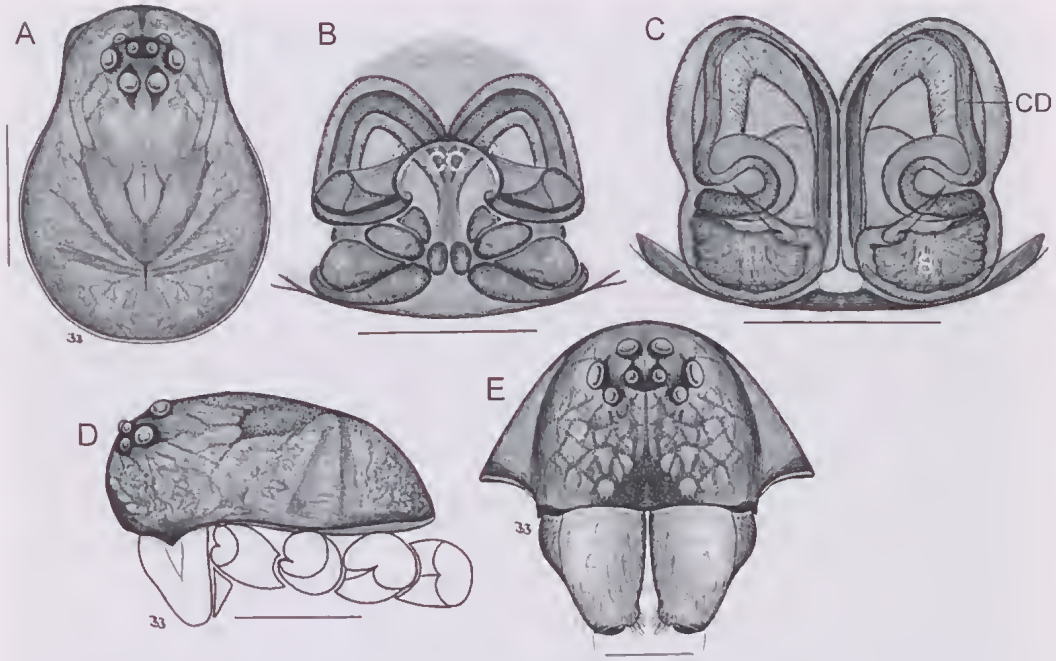

FIG. 2. *Tropasteron cleveland* female. A, carapace; B,C, epigyne; B, ventral, C, dorsal, scale 0.25mm; D,E, cephalothorax; D, lateral; E, frontal, scale 1mm. CD = copulatory duct, CO = copulatory opening, S = spermatheca.

DESCRIPTION. *Male* (holotype). Total length 4.12. Ceph 2.08 long, 1.56 wide, 0.84 high; cl/cw 1.33; sternum 1.04 long, 0.96 wide; sl/sw 1.08; abdomen 2.04 long, 1.44 wide.

Colour: Carapace orange brown. With dark fovea and dark bifurcate patches in front; sternum orange brown; chelicerae orange; maxillae and labium medium brown, distally white. Abdomen (Fig. 1A) sepia brown; dorsally with 2 pairs of white patches on top and 2-3 in front of the spinnerets; lateral with 1 white patch; ventrally dark brown. Legs medium brown, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV brown; femur I dark brown, II-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes: in 2 rows with 4 eyes, both rows procurved; AME smallest, PLE largest; eye group width 0.69 of headwidth; AME 0.10; ALE 0.12; PME 0.13; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.34; AME-AME 0.24; PME-PME 0.30. Clypeus 0.48 high; chilum undivided.

Male palp (Figs 1B,C, 3C): tegulum (LTA) a long spine, at least twice as long as wide; EP about as long as wide at base (Fig. 5A).

Female (paratype). Total length 4.92. Ceph 2.44 long, 1.68 wide, 0.96 high; cl/cw 1.45; sternum 1.08 long, 1.00 wide; sl/sw 1.08; abdomen 2.48 long, 1.92 wide.

Colour: As in male.

Eyes: AME smallest; PLE largest; eye group width 0.53 of headwidth; AME 0.10; ALE 0.12; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.12; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.24; PME-PME 0.34. Clypeus 0.60 high.

Epigyne: (Fig. 2B,C) with oval CO.

DISTRIBUTION. Queensland (Fig. 29). Known only from the summit of Mt Cleveland, a small, isolated mountain on the coast 25km E of Townsville. Open forest.

Tropasteron cardwell sp. nov.
(Figs 5B, 7, 29)

ETYMOLOGY. The type locality, a noun in apposition.

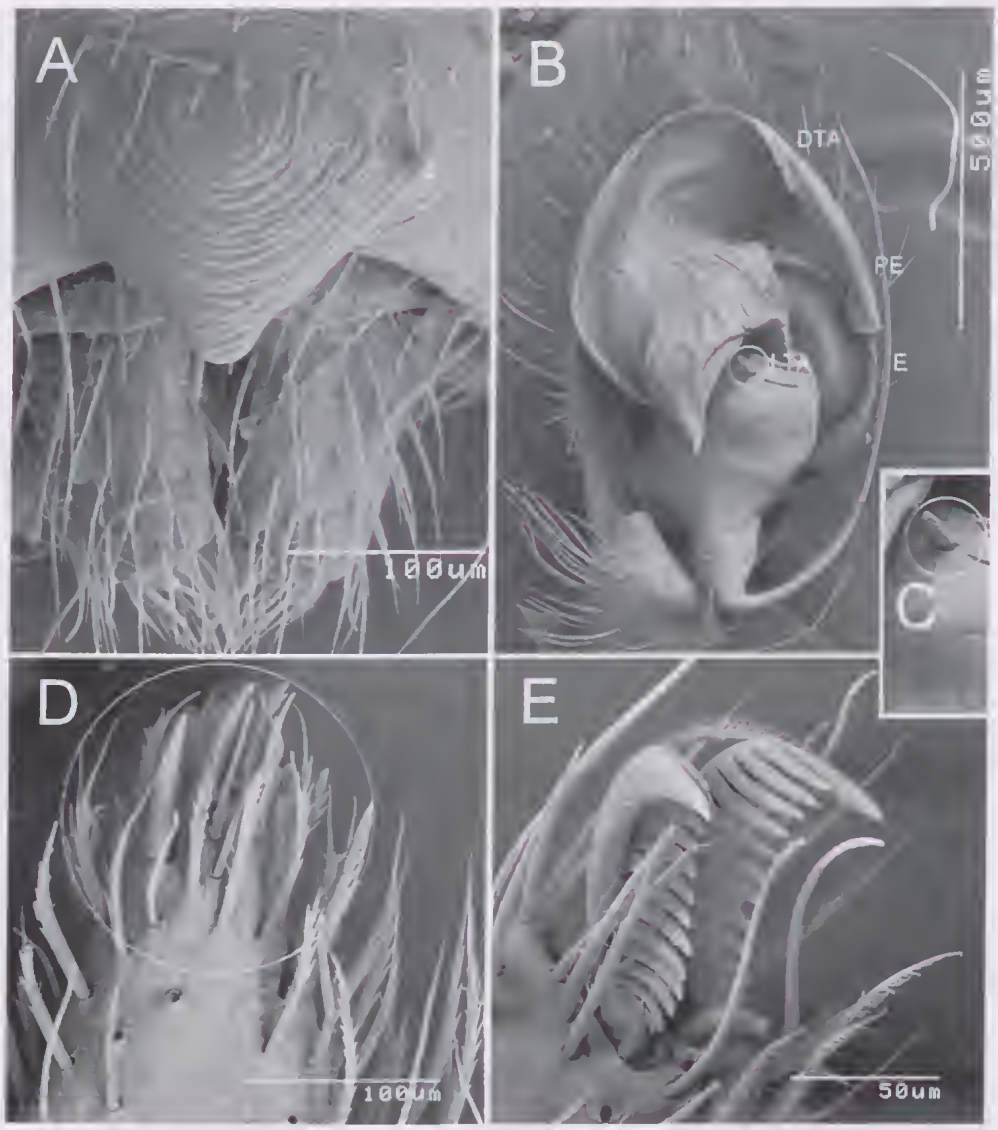

FIG. 3. *Tropasteron cleveland* male. A, pitted shield covers tracheal spiracle; B, palp ventral; C, LTA spine; D, tip of cymbium; E, tarsal claw 1st right leg.

MATERIAL. HOLOTYPE: ♂, Cardwell Ra, NE Qld, Upper Broadwater Ck Valley, 700m, rainforest, 18°18'S, 145°56'E, 18 Dec 1986-14 Jan 1987, GM, GT, SH, pitfall (QM S12235). PARATYPES: NE Qld: 2♀,1♂, same data as holotype (QM S57093); 1♀,1♂, same data as holotype (AM KS83917); 2♂, Cardwell Ra, Mt Macalister, 700m, rainforest, 18°19'S, 145°5'E, 20 Dec 1986, GM, GT, moss on trees and rocks (QM S25692); 9♂, same locality, 18°18'S, 145°56'E, 18 Dec 1986-14 Jan 1987, GM, GT, SH, flight intercept trap (QM S41929); 2♂, Upper Boulder Ck, 8km N of Tully, 250m, rainforest, 17°05'S, 145°54'S, 4-7 Dec 1989, GM, GT, HJ, pitfall (QM S46826); 1♂, Boulder Ck, Walter Hill Ra, rainforest, 250-600m, 17.05'S, 145.54'E, 24-27 Oct 1983, GM, DY, GT (QM S3808);1♂, Broadwater Pk, 35km NW Ingham, rainforest, 18°22'S, 145°57'E, 21-22 Dec 1986, SH (QM S12239); 1♂, as previous, 18°22'S, 145°57'E, 22 Dec 1986-3 Jan 1987, SH, pitfall (QM S12238); 7♂, Douglas Ck Rd, Kirrama SF, 800m, rainforest, 18°12'S, 145°45'E, 10 Dec 1986-11 Jan 1987, GM, GT, SH, flight intercept trap (QM S12240); 7♂, as previous, 26-30 Aug 1987, RR, pitfall (QM S12242); 9♂, Mt Smoko Rd, Kirrama Ra, 700m, rainforest, 18°09'S, 145°37'E, 10 Dec 1986-11 Jan 1987, GM, GT, SH, pitfall (QM S18179); 2♂, Kirrama Ra (Mt

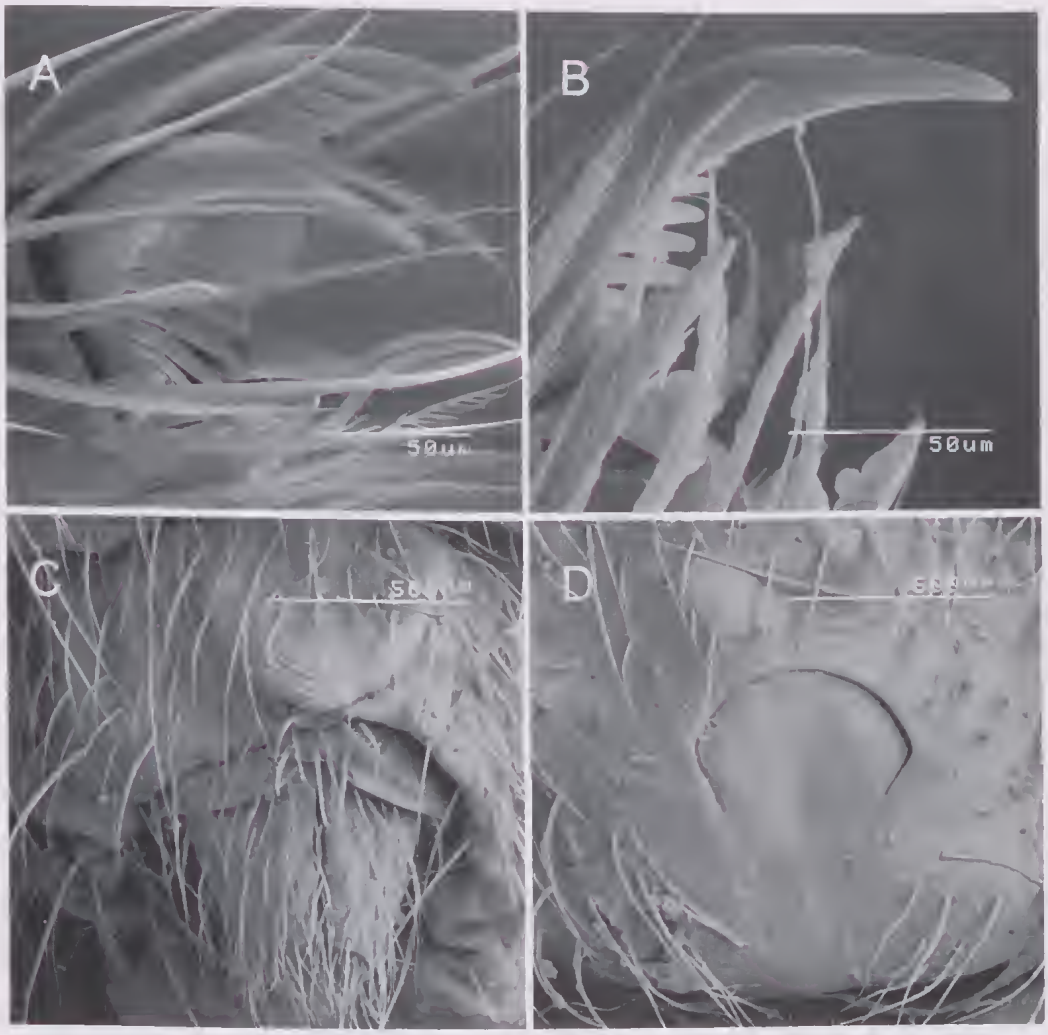

FIG. 4. *Tropasteron cleveland* female. A, tarsal claw 1st right leg B, palpal claw with teeth; C, pitted shield covers tracheal spiracle; D, CO of epigyne.

Hosie), 930m, rainforest, 18°11'S, 145°45'E, 11-Dec-86, GM, GT, Berlesate (QM S34852); 4♂. Kirrama Ra, Main Rd, west side, 700m, rainforest, 18°12'S, 145°45'E, 10 Dec 1986-11 Jan 1987, GM, GT, SH, pitfall (QM S12263); 2♀,2♂, Kirrama Ra, 700m, 18°06'S, 145°42'E, 9 Dec 1986, GM, GT, sieved litter (QM S25683); 2♂, Kirrama Ra, Yuccabine Ck, 700m, 18°12'S, 145°45'E, 10 Dec 1986, GM, GT, sieved litter (QM S25694); 2♂, Kirrama Ra, Douglas Ck Rd, 800m, 18°12'S, 145°45'E, 10 Dec 1986-11 Jan 1987, GM, GT, SH, pitfall (QM S18177); 2♂, Gayundah Ck, Hinchinbrook Is, 10m, rainforest, 18°22'S, 146°15'E, 8-17 Nov 1984, VD, JG, pitfall (QM S25791): 1♀,9♂, as previous (QM S25721); 1♂, as previous, 18°22'S, 146°13'E, 8-18 Nov 1984, GM, GT, DC, pitfall (QM S3800).

DIAGNOSIS. Very similar in colour pattern and body shape to *T. splendens* and *T. malbon*, differs in colour pattern by: abdomen without weak scutum and ventrally with 1 pair of small white spots. *T. cardwell* has shorter legs and different shape of palp with long spine, at least twice as long as wide (LTA).

DESCRIPTION. *Male* (holotype). Total length 4.24. Ceph 2.20 long, 1.60 wide, 1.00 high; el/ew 1.37; sternum 1.08 long, 0.96 wide; sl/sw 1.12; abdomen 2.04 long, 1.32 wide.

Colour: carapace orange brown. With dark fovea and dark bifureate patches in front; sternum orange brown; chelicerae orange; maxillae and

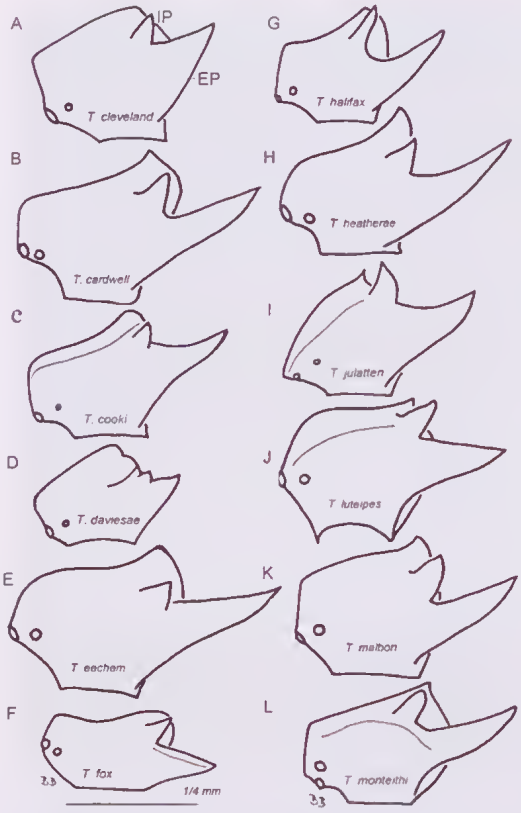

FIG. 5. A-L, tibia (dorsal view) of *Tropasteron* spp; A, *T. cleveland*; B, *T. cardwell*; C, *T. cooki*; D, *T. daviesae*; E, *T. eacham*; F, *T. fox*; G, *T. halifax*; H, *T heatherae*; I, *T. julatten*; J, *T. luteipes*; K, *T. malbon*; L, *T. monteithi*. Scale 0.25mm. EP = external prong on dorso-retrolateral apopysis; IP = internal prong on dorso-retrolateral apopysis.

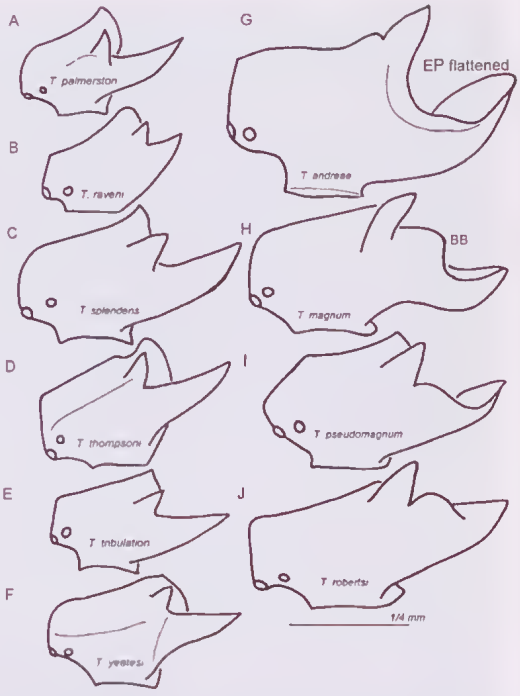

FIG. 6. A-J, tibia (dorsal view) of *Tropasteron* spp; A, *T. palmerston*; B, *T. raveni*; C, *T. splendens*; D, *T. thompsoni*; E, *T. tribulation*; F, *T. yeatesi*; G, *T. andreae*; H, *T magnum*; I, *T. pseudomagnum*; J, *T. robertsi*. Scale 0.25mm.

labium medium brown, distally white. Abdomen (Fig. 7C, D) sepia brown; frontally with 1 pair of small white dots; dorsally with 2 pairs of white patches on top and 2-3 in front of the spinnerets; lateral with 1 white patch; ventrally dark brown; with 1 pair of white patches near tracheal spiracle. Legs pale brown, with darker brown lateral stripes; coxae I-IV white or pale; trochanter I-IV brown; femur I-IV proximal part white becoming continuously dark brown distally; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.60 of headwidth; AME 0.08; ALE 0.12; PME 0.13; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.20; PME-PME 0.30. Clypeus 0.52 high.

Male palp (Fig. 7A, B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct semicircular; EP at least twice as long as wide at base (Fig. 5B).

Female (paratype). Total length 4.20. Ceph 2.20 long, 1.44 wide, 0.96 high; cl/cw 1.52; sternum 0.92 long, 0.88 wide; sl/sw 1.04; abdomen 2.00 long, 1.44 wide.

Eyes: AME smallest; eye group width 0.57 of headwidth; AME 0.08; ALE 0.12; PME 0.13; PLE 0.13; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.12; ALE-PLE 0.04; eyes group AME-PME 0.38; AME-AME 0.20; PME-PME 0.30. Clypeus 0.52 high.

Epigyne (Fig. 7E, F): Wider than long, with very flat, broadly oval CO (Fig. 7E, F).

DISTRIBUTION. Queensland, Wet Tropics blocks 12, 13 and 15 (Fig. 29). Occurs widely on the Kirrama Range, on the eastern rims of the Cardwell and Walter Hill Ranges, and on nearby Hinchinbrook Island. Rainforest.

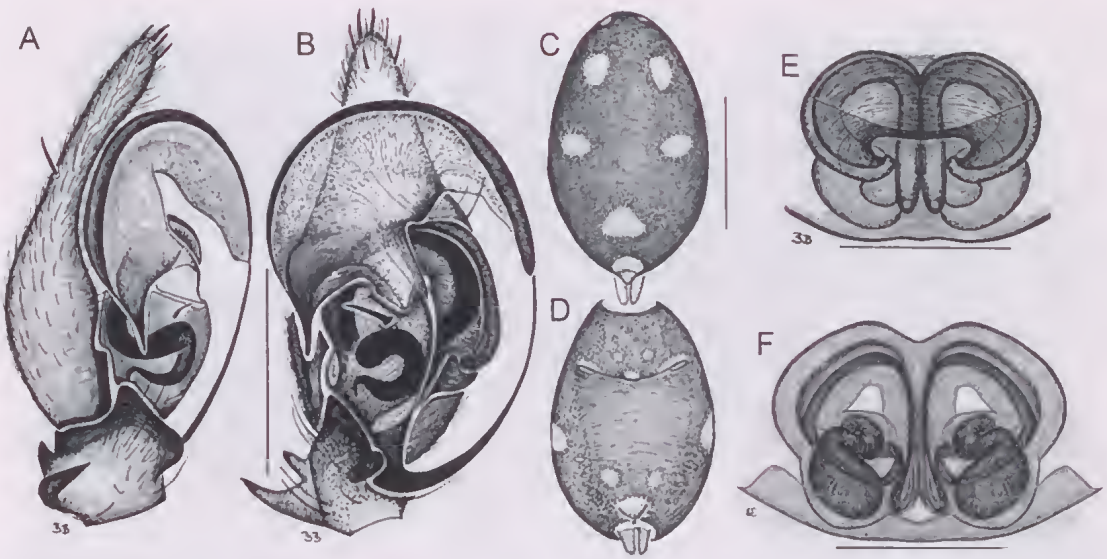

FIG. 7. *Tropasteron cardwell*. A,B, palp; A, lateral; B, ventral; scale 0.25mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

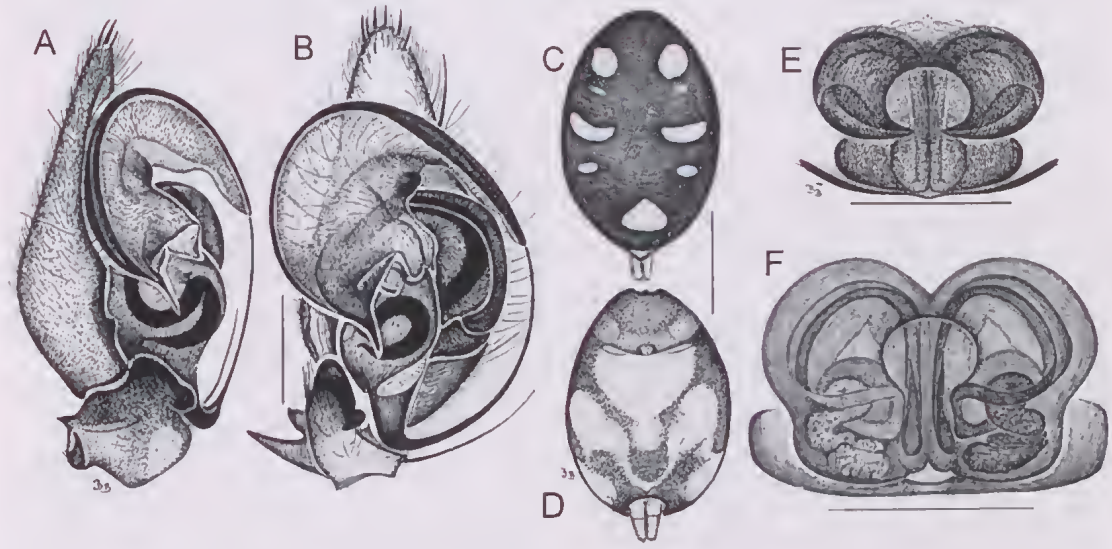

FIG. 8. *Tropasteron cooki*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

Tropasteron cooki sp. nov.
(Figs 5C, 8, 31B)

ETYMOLOGY. For Douglas Cook of the Queensland Museum, one of the collectors.

MATERIAL. HOLOTYPE: ♂, North Bell Peak, Malbon Thompson Ra, NE Qld, 17°07'S, 145°53'E, 20-22 Nov 1990, GM, GT, pitfall (QM S57007). PARATYPES: NE Qld: 1♀,7♂, as for holotype (QM S25696); 1♀,1♂, Bell Peak North, 10km E Gordonvale, 850-1000m, rainforest, 17°06'S, 145°53'E, 13 Oct 1982, GM, DY, GT, sieved litter (QM S4235); 2♀,1♂, Mt Edith Rd, Lamb Ra., 900m, rainforest, 17°06'S, 145°37'E, 12 Oct 1982, GM, DY, GT, sieved litter (QM S3798); 3♀,1♂, North Bell Peak, via Gordonvale, 900m, rainforest, 17°05'S, 145°53'E, 16 Sep 81, GM, DC (QM S3766); 5♂, North-South Bell Pk saddle, Malbon Thompson Ra, 17°07'S, 145°54'E, 20-21 Nov 1990, GM, GT, pitfall (QM S25788).

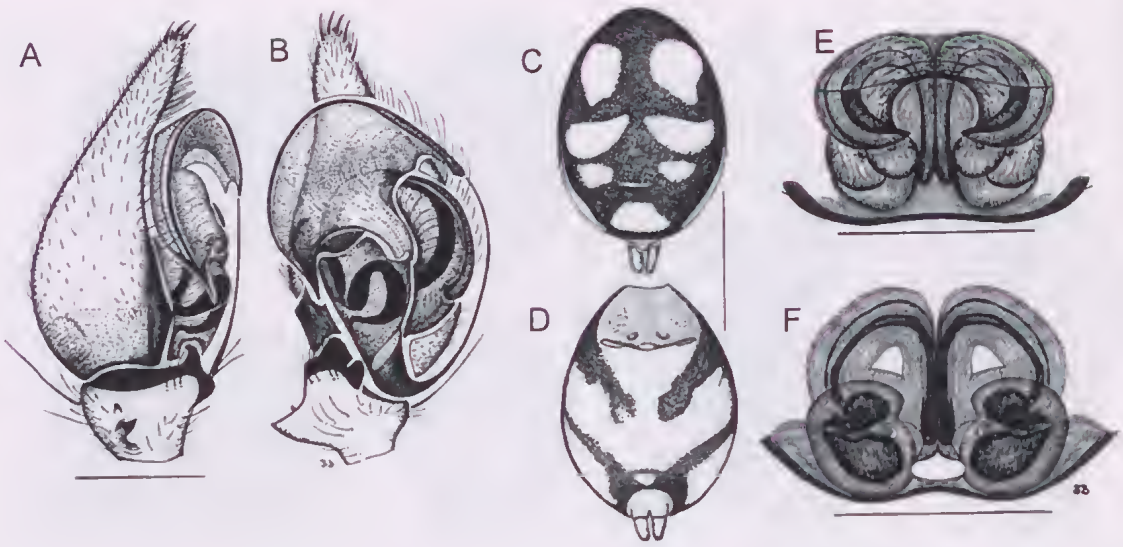

FIG. 9. *Tropasteron daviesae*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

DIAGNOSIS. *T. cooki* is similar to *T. yeatesi* but differs from all other species by abdomen without frontal spots and with 4 pairs of white patches on top. Differs from *T. yeatesi* in only 2 spots in front of the spinnerets. Male palp with short spine (LTA), about as wide as long.

DESCRIPTION. *Male* (holotype). Total length 4.08. Ceph 2.00 long, 1.60 wide, 1.04 high; cl/ew 1.25; sternum 1.04 long, 0.88 wide; sl/sw 1.18; abdomen 2.08 long, 1.36 wide.

Colour: carapace orange brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 8C,D) sepia brown; dorsally with 4 pairs of white patches on top and 2 in front of the spinnerets; lateral with chevrons; ventrally pale brown; mottled with brown. Legs pale brown to medium brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME smallest, PLE largest; eye group width 0.58 of headwidth; AME 0.09; ALE 0.14; PME 0.13; PLE 0.16; AME-AME 0.04; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.02; eyes group AME-PME 0.34; AME-AME 0.20; PME-PME 0.30. Clypeus 0.44 high; chilum divided.

Male palp (Fig. 8A,B): tegulum (LTA) a short spine, about as wide as long; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 5C).

Female (paratype). Total length 6.12. Ceph 2.76 long, 1.96 wide, 1.36 high; cl/ew 1.40; sternum 1.00 long, 1.00 wide; sl/sw 1.00; abdomen 3.36 long, 2.56 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.54 of headwidth; AME 0.09; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.06; PME-PME 0.06; PME-PLE 0.16; ALE-PLE 0.06; eyes group AME-PME 0.40; AME-AME 0.20; PME-PME 0.34. Clypeus 0.68 high.

Epigyne: wider than long, anteriorly wider, with semicircular CO (Fig. 8E,F).

Variation: Females are bigger than males and have more chevrons.

DISTRIBUTION. Queensland, Wet Tropics blocks 7 and 11 (Fig. 31B). Known only from high elevations on the Lamb Range and the Bell Peak region of the Malbon Thompson Range. Rainforest.

Tropasteron daviesae sp. nov.
(Figs 5D, 9, 30B)

ETYMOLOGY. For Dr Valerie Davies, the main founder of the spider collection of the Queensland Museum.

MATERIAL. HOLOTYPE: ♂, Upper Boulder Ck, Walter Hill Ra, NE Qld, 850-1000m, rainforest, 17°05'S, 145°54'E, 17-18 Nov 1984, VD, GM, JG, DC, GT, pitfall (QM S57092). PARATYPES: NE Qld: 1♂, same data as holotype but, 900m, 27 Oct 1983, GM, DY, GT, sieved litter (QM S3806); 1♂, as previous, 200-650m, 24-27 Oct

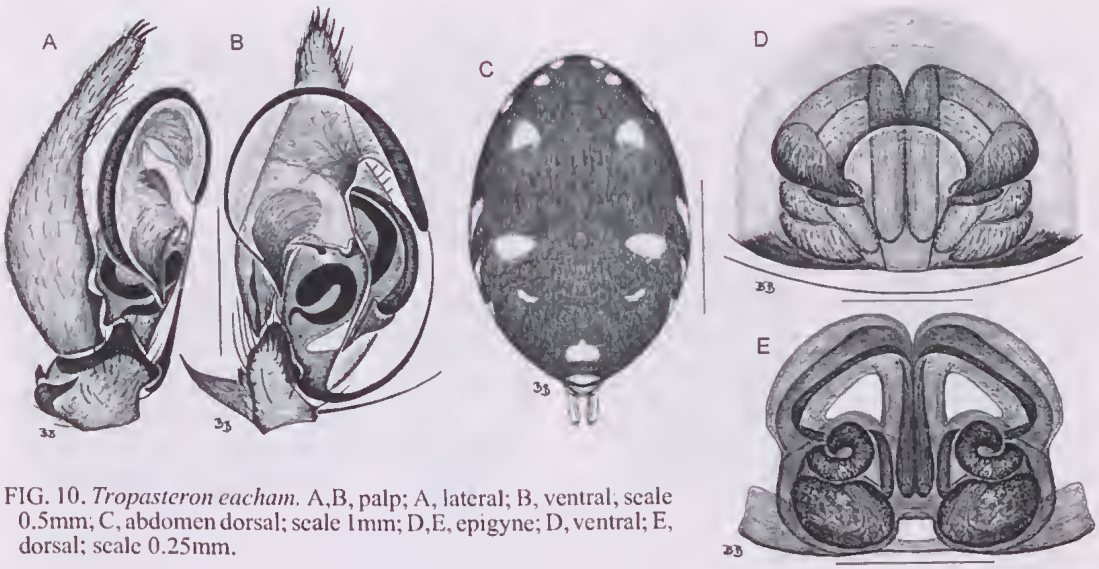

FIG. 10. *Tropasteron eacham*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C, abdomen dorsal; scale 1mm; D,E, epigyne; D, ventral; E, dorsal; scale 0.25mm.

1983 (QM S3787); 2♂, as previous, 850-1000m, 17-18 Nov 1984, VD, GM, DC, GT, pitfall (QM S3785); 1♂, as previous (QM S4266); 1♂, Maalan SF (NQ 12), 17°35'S, 145°36'E, 26 Nov 1992-15 Apr 1993, R., J. & S. Raven, P. & E. Lawless, pitfall (QM S24368); 1♂, U Boulder Ck, 10km N Tully, 800m, 17°05'E, 145°54'S, 4-7 Dec 1989, GM, GT, HJ, pitfall (QM S41523); 1♀,12♂, Maalan SF (NQ 12), 17°35'30"S, 145°36'45"E, 25 Jul 1992-26 Nov 1992, RR, P. & E. Lawless, MS, pitfall (QM S24486); 1♂, as previous (AM KS 83918)..

DIAGNOSIS. One of the smallest species, it differs from all others by Ep very short (Fig. 5D), no palpal spine (LTA) and abdomen with 3 pairs of big pale dorsal spots but without frontal spots.

DESCRIPTION. *Male* (holotype). Total length 3.64. Ceph 1.88 long, 1.32 wide, 0.88 high; cl/ew 1.42; sternum 0.88 long, 0.80 wide; sl/sw 1.10; abdomen 1.76 long, 1.28 wide.

Colour: carapace yellow orange; sternum, chelicerae, maxillae and labium yellow, distally white. Abdomen sepia brown (Fig. 9C,D); frontally without or with 1 pair of weak small white dots; dorsally with 3 pairs of big white patches on anterior part and 2 to 3 in front of spinnerets; lateral with chevrons; ventrally white; mottled with brown. Legs pale to white.

Eyes: AME smallest; eye group width 0.59 of headwidth; AME 0.09; ALE 0.11; PME 0.11; PLE 0.11; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.30; AME-AME 0.22; PME-PME 0.26. Clypeus 0.32 high.

Male palp (Fig. 9A,B): tegulum (LTA) absent; sperm duct inverted U-shaped; EP about as long as wide at base (Fig. 5D).

Female (paratype). Total length 3.52. Ceph 1.92 long, 1.20 wide, 0.92 high; cl/ew 1.60; sternum 0.84 long, 0.84 wide; sl/sw 1.00; abdomen 1.60 long, 1.08 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.5 of headwidth; AME 0.06; ALE 0.10; PME 0.08; PLE 0.10; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.03; eyes group AME-PME 0.28; AME-AME 0.16; PME-PME 0.22. Clypeus 0.40 high.

Epigyne: wider than long, anteriorly wider, with semicircular CO (Fig. 9E, F).

Variation: in some specimens, the abdominal dots can be expanded.

DISTRIBUTION. Queensland, Wet Tropics block 12 (Fig. 30B). Occurs only at high elevations along the Walter Hill Range. Rainforest.

Tropasteron eacham sp. nov.
(Figs 5E, 10A-E, 30A)

ETYMOLOGY. The type locality is near Lake Eacham; a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Mt Hypipamee NP, The Crater, NE Qld, 17°25'29"S, 145°29'00"E, 2-May-98, G. Milledge, pitfalls open, 25 Apr - 2 May 1998 (AM KS 77352). PARATYPES: NE Qld: 1♀,12♂, same data as holotype (AM KS 55635); 3♂, Lake Eacham, 750m, 17°17'S, 145°38'E, 9 Dec 1989-14 Jan 1990, GM, GT, HJ,

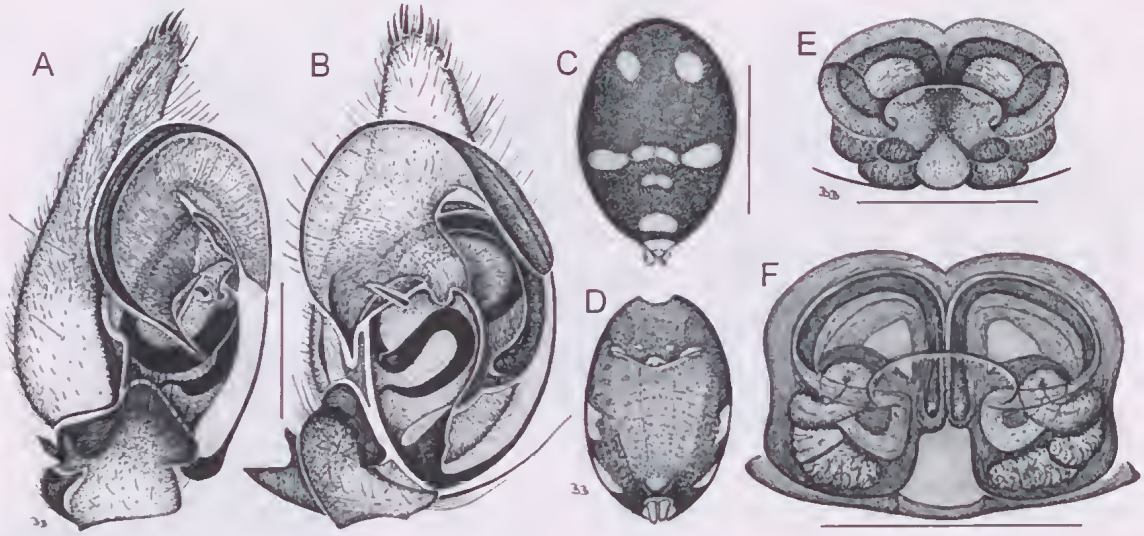

FIG. 11. *Tropasteron fox*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

pitfall (QM S25961); 2♂, Mt Father Clancy, 9km S Millaa Millaa, 800m, 17°35'S, 145°38'E, 6-14 Dec 1988, GM, GT, flight intercept trap (QM S23056); 1♂, Wongabel State Forest (NQ 26), 17°19'S, 145°29'E, 5 Nov 1991-23 Jul 1992, RR, PL, MS, pitfall (QM S24208); 1f, 2♂, as previous, 26 Nov 1992-15 Apr 1993, R., J. & S. Raven, P. & E. Lawless, pitfall (QM S19748); 4♂, Maalan SF, 1000m, rainforest, 17°35'S, 145°35'E, 20-24 Apr 1978, VD, RR (QM S3851).

DIAGNOSIS. Similar to *T. julatten* and *T. luteipes* with 2 frontal and 1 small frontal lateral pair of small white dots but *T. eacham* as the largest species, differs from *T. julatten* by long palpal spine (LTA) and from *T. luteipes* by legs with indistinct colour pattern.

DESCRIPTION. *Male* (holotype). Total length 4.76. Ceph 2.44 long, 1.72 wide, 1.08 high; cl/ew 1.42; sternum 1.08 long, 0.96 wide; sl/sw 1.12; abdomen 2.32 long, 1.60 wide.

Colour: carapace orange brown. Sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 10C) sepia brown; frontally with 2 pairs of small white dots, and 1 small lateral pair; dorsally with 3 pairs of white patches on top and 1-2 in front of the spinnerets; lateral with 3-4 white patches, first circular, others elongate; ventrally dark brown; with 1 pair of white patches near tracheal spiracle. Legs medium brown; coxae I-IV white or pale; trochanter I-IV brown; femur I-IV proximal part white, distal part pale brown, or I-IV dark brown; tibia I distally white.

Eyes: AME smallest; eye group width 0.60 of headwidth; AME 0.12; ALE 0.12; PME 0.16; PLE 0.16; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.42; AME-AME 0.28; PME-PME 0.36. Clypeus 0.56 high.

Male palp (Fig. 10A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted U-shaped.

Female (paratype). Total length 5.76. Ceph 2.72 long, 1.84 wide, 1.28 high; cl/cw 1.48; sternum 1.12 long, 1.04 wide; sl/sw 1.08; abdomen 3.04 long, 2.40 wide.

Colour: as in males.

Eyes: AME smallest; eye group width 0.57 of headwidth; AME 0.12; ALE 0.14; PME 0.16; PLE 0.16; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.16; ALE-PLE 0.06; eyes group AME-PME 0.42; AME-AME 0.28; PME-PME 0.36. Clypeus 0.68 high.

Epigyne: wider than long, CO inverted flask-shaped (Fig. 10D,E).

DISTRIBUTION. Queensland, Wet Tropics blocks 8, 9 and 12. (Fig. 30A). Occurs on the Atherton Tableland and on mountains immediately to the west (Hugh Nelson Range) and south (Mt Father Clancy). Rainforest.

Tropasteron fox sp. nov.
(Figs 5F, 11, 29B)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Seaview Ra, NE Qld, Mt Fox Rd, 600m, rainforest, 18°50'S, 145°50'E, 15 Dec 1986-2 Jan 1987, GM, GT, SH, pitfall (QM S56866). PARATYPES: NE Qld: 5♀,17♂, as for holotype (QM S18178); 1♀,2♂, as previous, 15-Dec-86, GM, GT, (QM S25690); 1♂, Cardwell Gap (NQ 5), 18°31'53"S, 146°11'E, 26 Nov 1992-16 Apr 1993, RR, PL, pitfall (QM S24565); 1♀,2♂, Wallaman Falls Rd, sieved litter, 500m, rainforest, 18°35'S, 145°51'E, 1 Jan 87, SH, pitfall (QM S25704); 2♀♂,9♂, Wallaman Falls, via Ingham, sieved litter, 500m, rainforest, 18°36'S, 145°48'E, 14 Dec 1986-2 Jan 1987, GM, GT, SH, pitfall (QM S18176); 1♀,1♂, as previous (AM KS83919); 1♂, as previous, 1 Oct 1980, GM, pitfall (QM S3761); 12♂, Wallaman Falls Rd, junction, 650m, rainforest, 18°39'S, 145°52'E, 5-12 Feb 1996, GM, pitfall (QM S41434); 3♂, as previous (QM S38223); 1♂, Cardwell Gap, open forest, 18°32'S, 146°11'E, 4-12 Feb 1998, GM, DC, pitfall (QM S41923).

DIAGNOSIS. One of the smallest species, it differs from all others by abdomen with 2 pairs of white dots on the anterior part, second pair forming a horizontal stripe, 3 spots in front of the spinnerets and short EP.

DESCRIPTION. *Male* (holotype). Total length 3.44. Ceph 1.76 long, 1.24 wide, 0.84 high; el/ew 1.42; sternum 0.84 long, 0.80 wide; sl/sw 1.05; abdomen 1.68 long, 1.24 wide.

Colour: carapace orange brown. Sternum orange brown; chelicerae medium brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 11C, D) sepia brown; dorsally with 2 pairs of white patches on the anterior part, second pair forming a horizontal stripe, and 3 spots in front of the spinnerets; lateral with 2 elongate white patches, first one broad; ventrally pale brown. Legs pale to white; coxae I-IV white or pale; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.57 of headwidth; AME 0.08; ALE 0.10; PME 0.10; PLE 0.12; AME-AME 0.10; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.06; ALE-PLE 0.02; eyes group AME-PME 0.26; AME-AME 0.18; PME-PME 0.24. Clypeus 0.38 high.

Male palp (Fig. 11A,B): tegulum (LTA) a short spine, about as wide as long; sperm duct inverted U-shaped; EP about as long as wide at base (Fig. 5F).

Female (paratype). Total length 3.76. Ceph 1.88 long, 1.12 wide, 0.64 high; el/ew 1.68; sternum 0.80 long, 0.76 wide; sl/sw 1.05; abdomen 1.88 long, 1.36 wide.

Colour: as in male.

Eyes: AME smallest, or PLE largest; eye group width 0.56 of headwidth; AME 0.07; ALE 0.10; PME 0.10; PLE 0.12; AME-AME 0.02; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.30; AME-AME 0.16; PME-PME 0.24.

Clypeus 0.40 high.

Epigyne: wider than long, with very flat, broadly oval CO (Fig. 11E,F).

Variation: the lateral white stripes can be connected with the pale ventral side of the abdomen.

DISTRIBUTION. Queensland, Wet Tropics blocks 13 and 14 (Fig. 29B). Occurs on the Seaview Range and the southern end of the Cardwell Range, both adjacent to the valley of the Herbert River. Rainforest and open forest.

Tropasteron halifax sp. nov.
(Figs 5G, 12, 29A)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Mt Halifax, NE Qld, summit, 1050m, 19°07'S, 146°23'E, 1 Jan-20 Mar 1991, A. Graham, pit (QM S56919). PARATYPES: NE Qld: 1♀,4♂, as for holotype (QM S25689); 1♂, 7km WNW of Paluma (Site 32), 19°05'S, 146°06'E, 16 Dec 1988-13 Jan 1989, R. Storey, G. Dickinson, flight intercept trap (QM S25749); 1♀,1♂, Paluma, Mt Spec, rainforest, 18°57'S, 146°11'E, 20 Jan-10 Feb 1983, NPWS per K. Smith, pitfall (QM S4448); 5♂, as previous, 20 Dec 1982-20 Jan 1983, K. McDonald (QM S4385); 2♂, Paluma Dam Rd, Site 2, 720m, rainforest, 19°14'S, 146°13'E, 17 Nov 1990-8, Dec 1990, GM, J. Seymour, flight intercept trap (QM S25958); 1♀,3♂, Paluma Ra 75km NW Townsville, 18°47'S, 146°19'E, 18°1.1982, B. & M. Baehr (QM S56920); 6♂, 12km WSW Paluma (Site 33), Mareeba DPI, 19°05'S, 146°06'E, 16 Dec 1988-13 Jan 1989, R. Storey, G. Dickinson, flight intercept trap (QM S25747); 12♂, Wallaman Falls, via Ingham, 500m, rainforest, 18°36'S, 145°48'E, 14 Dec 1986-2 Jan 1987, GM, GT, SH, pitfall (QM S12262); 1♂, Paluma Dam Rd. Site 5, 850m, 18°57'S, 146°09'E, 17 Nov-8 Dec 1990, GM, J. Seymour, pitfall (QM S46855); 11♂, Paluma Dam Rd, Site 5, 850m, 19°01'S, 146°13'E, 8 Dec 1990-5 Feb 1991, GM, J. Seymour, pitfall (QM S46850); 1♀,12♂, Paluma Dam Rd, Site 3, 800m, 19°01'S, 146°13'E, 08 Dec 1990-05 Feb 1991, GM, Seymour, pitfall (QM S31890); 1♂, Paluma Dam Rd, Site 5, 850m, 19°01'S, 146°13'E, 08 Dec 1990-5 Feb 1991, GM, J. Seymour, flight intercept trap (QM S41921); 3♂, Paluma Dam Rd, Site 2, 720m, rainforest, 19°14'S, 146°13'E, 17 Nov-8 Dec 1990, GM, J. Seymour, pitfall (QM S46891); 15♂, Mt Halifax, 19°07'S, 146°23'E, 1st wk Dec 90-8/1/91, A. Graham, pitfall (QM S33735).

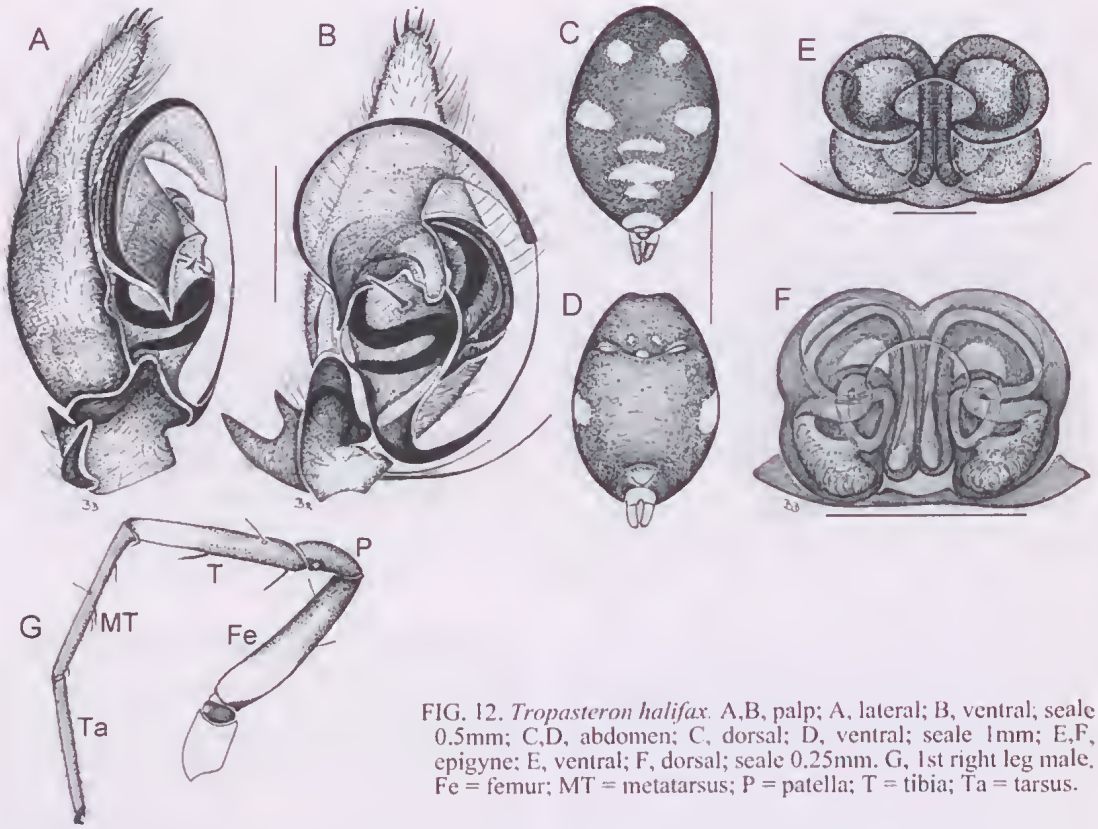

FIG. 12. *Tropasteron halifax*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm. G, 1st right leg male. Fe = femur; MT = metatarsus; P = patella; T = tibia; Ta = tarsus.

DIAGNOSIS. *T. halifax*, a small species with very long palpal spine (LTA), differs from all other species by abdomen without frontal spots and with 2 pairs of big white dots on the anterior part and 3-4 in front of the spinnerets.

DESCRIPTION. *Male* (holotype). Total length 3.72. Ceph 1.92 long, 1.28 wide, 0.80 high; cl/cw 1.50; sternum 0.84 long, 0.80 wide; sl/sw 1.05; abdomen 1.80 long, 1.20 wide.

Colour: carapace orange brown; sternum orange brown; chelicerae medium brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 12C,D) sepia brown; dorsally with 2 pairs of big white patches on the anterior part and 3-4 in front of the spinnerets; lateral with 1-2 white stripes, first one broad; ventrally pale brown. Legs yellow, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.62 of headwidth; AME 0.08; ALE 0.10; PME 0.12; PLE 0.16; AME-AME 0.04; AME-ALE 0.03; PME-PME 0.04; PME-PLE 0.06; ALE-PLE 0.02; eyes group AME-PME 0.32; AME-AME 0.20; PME-PME 0.28. Clypeus 0.40 high.

Male palp (Fig. 12A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 5G).

Female (paratype). Total length 4.00. Ceph 2.16 long, 1.28 wide, 0.92 high; cl/cw 1.68; sternum 0.84 long, 0.84 wide; sl/sw 1.00; abdomen 1.84 long, 1.32 wide.

Colour: as in male.

Eyes: AME smallest, or PLE largest; eye group width 0.66 of headwidth; AME 0.08; ALE 0.10; PME 0.12; PLE 0.14; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.03; eyes group AME-PME 0.03; AME-AME 0.18; PME-PME 0.28. Clypeus 0.48 high.

Epigyne: wider than long, with broadly oval CO (Fig. 12E,F).

DISTRIBUTION. Queensland, Wet Tropics blocks 14 and 16 (Fig. 29A). Occurs along the

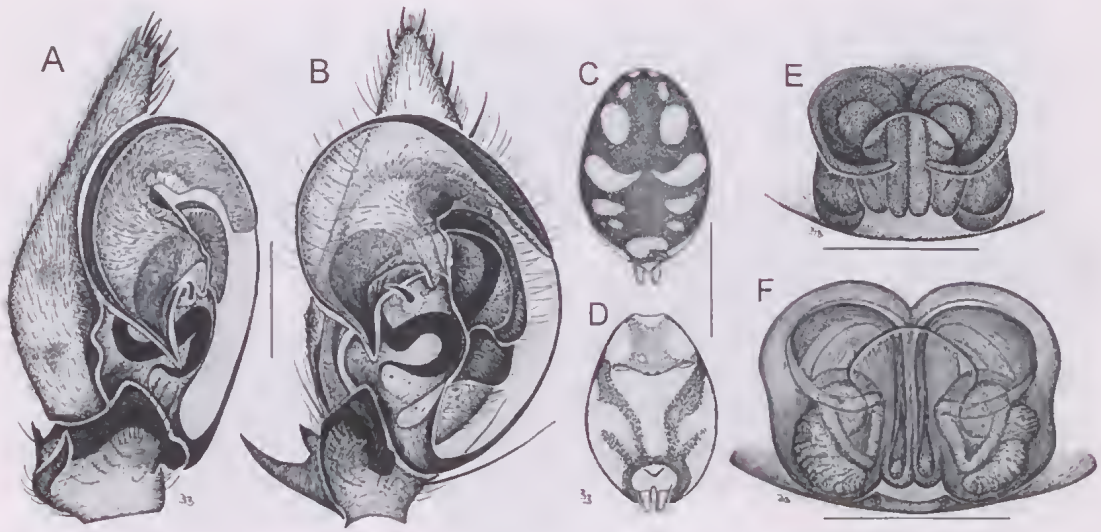

FIG. 13. *Tropasteron heatherae*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

summit of the subcoastal ranges from Wallaman Falls south to Paluma. Rainforest.

Tropasteron heatherae sp. nov.
(Figs 5H, 13, 31B)

ETYMOLOGY. For Heather Janetzki of the Queensland Museum, a collector of the types.

MATERIAL. HOLOTYPE: ♂, Stewart Ck, NE Qld, 4km NNE Mt Spurgeon, Camp 1, 1250-1300m, 16°24'S, 145°13'E, 15-20 Oct 1991, GM, DC, HJ, L. Roberts, pitfall (QM S57008). PARATYPES: NE Qld: 7♂, as for holotype (QM S25799); 2♂, Mt Spurgeon, 7km N of (amp 2), 1250m, 15°28'18"S, 145°13'18"E, 17-19 Oct 1991, GM, DC, L. Roberts, pitfall (QM S57009); 1♂, Mossman Bluff Track, 5-10km W Mossman, Site 9, 1260m, rainforest, 16°39'S, 145°34'E, 17-31 Dec 1988, GM, GT, ANZSES Expedition, flight intercept trap (QM S18170); 1♀,1♂, as previous, 1-19 Jan 1989 (QM S18164); 1♂, as previous, Site 7, 1000m, 16°28'S, 145°22'E, 20 Dec 1989-15 Jan 1990, pitfall (QM S25763); 1♂, as previous, 1300m, 21 Dec 1989, GM, GT (QM S25800); 1♂, Carbine Tableland, plane crash site, 1330m, 16°24'27"S, 145°16'20"E, 27-28 Nov 1990, GM, GT, DC, R. Sheridan, HJ (QM S21478); 1♂, as previous, pitfall (QM S21479); 1♂, as previous (QM S26109); 1♂, Carbine Tableland, Mossman Bluff camp, 1000m, 16°27'52"S, 145°17'12"E, 30 Nov 1990, GM, HJ (QM S25687); 1♂, Carbine Tblnd, above fern patch, Devils Thumb, 16°23'S, 145°17'E, 26-27. Nov 1990, GM, HJ, pitfall (QM S25808); 3♂, Cape Tribulation, 4.5km W (Site 9), 760m, rainforest, 16°05'S, 145°26'E, 23 Sep-7 Oct 1982, GM, DY, GT, pitfall (QM S4290); 1♂, Mt Demi, 7km SW Mossman, 1100m, rainforest, 16°03'S, 145°19'E, 29 Oct 1983, DY, GT (QM S3804); 1♂, Devils Thumb, 10km NW Mossman, 1150m, rainforest, 16°23'S, 145°17'E, 9 Oct 1982, GM, DY, GT (QM S4255); 4♂, Kamak-Devils Thumb, 8-12km NW Mossman, Site 10, 1080m, 16°23'S, 145°17'E, 26 Dec 1989-15 Jan 1990, ANZSES expedition, pitfall (QM S18175); 1♂, Mt Pieter Botte, 950m, 16°04'S, 145°24'E, 21 Nov- 8 Dec 1993, GM, HJ, Roberts, pitfall (QM S47060); 3♂, Devils Thumb, 12km NW Mossman, 1000m, rainforest, 16°23'S, 145°17'E, 26-27 Dec 1989, ANZSES expedition, pitfall (QM S18388); 3♂, Kamak-Devils Thumb, 8-12km NW Mossman, Site 5, 440m, 16°23'S, 145°17'E, 26 Dec 1989-15 Jan 1990, ANZSES expedition (QM S25130); 1♂, as previous (QM S25124); 2♂, as previous, Site 6, 900m, 16°23'S, 145°17'E, 26 Dec 1989-15 Jan 1990, ANZSES expedition (QM S29967); 1♂, Mossman Bluff Track, 5-10km W Mossman, Site 7, 1000m, rainforest, 16°28'S, 145°22'E, 20 Dec 1989-15 Jan 1990, GM, GT, ANZSES Expedition (QM S41543); 4♂, as previous, 16-30 Dec 1988 (QM S21701); 3♂, as previous, Site 9, 1260m, rainforest, 20 Dec 1989-15 Jan 1990 (QM S33951); 1♂, as previous, Site 9, 1260m, 16°25'S, 145°2'E, 17-31 Dec 1988 (QM S40865); 2♂, as previous, Site 10, 10km W Mossman, 1300m, rainforest, 16°25'S, 145°2'E, 20 Dec 1989-15 Jan 1990 (QM S34065); 2♂, Windsor Tableland, site 4, 1270m, 16.14'33"S, 145.01'03"E, 27 Dec1988-9 Jan 1989, E. Schmidt, ANZSES Expedition, FIT (QM S4939).

DIAGNOSIS. Differs from all other species by abdomen with 1 or 2 pairs of white spots frontally and with 4 pairs on top and 2 in front of the spinnerets, second transverse can form 1 line.

DESCRIPTION. *Male* (holotype). Total length 3.84. Ceph 2.04 long, 1.48 wide, 0.88 high; cl/cw

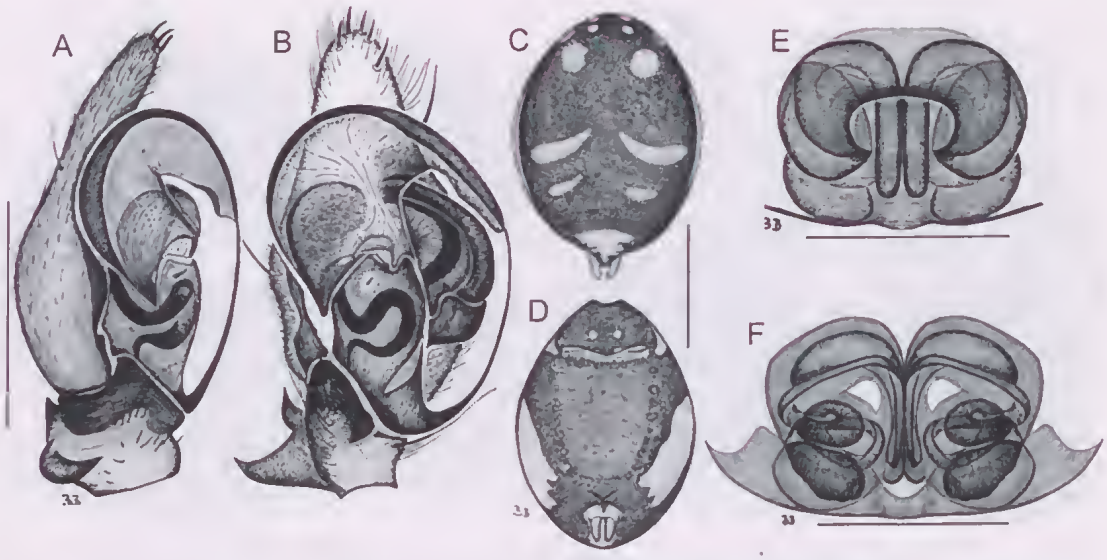

FIG. 14. *Tropasteron julatten*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

1.38; sternum 0.92 long, 0.88 wide; sl/sw 1.04; abdomen 1.80 long, 1.20 wide.

Colour: carapace orange brown; sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 13C,D) sepia brown; frontally with 1-2 pairs of small white dots; dorsally with 4 pairs of white patches on top and 2 in front of the spinnerets, second transverse can form 1 line; lateral with chevrons; ventrally pale brown; mottled with brown. Legs pale brown, medium brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes: AME smallest; eye group width 0.57 of headwidth; AME 0.10; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.03; PME-PME 0.02; PME-PLE 0.08; ALE-PLE 0.03; eyes group AME-PME 0.34; AME-AME 0.22; PME-PME 0.30. Clypeus 0.40 high; chilum divided.

Male palp (Fig. 13A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct semicircular; EP at least twice as long as wide at base (Fig. 5H).

Female (paratype). Total length 5.56. Ceph 2.76 long, 1.80 wide, 1.36 high; cl/cw 1.53; sternum 1.20 long, 1.08 wide; sl/sw 1.11; abdomen 2.80 long, 1.96 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.52 of headwidth; AME 0.10; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.06; PME-PME 0.06; PME-PLE 0.16; ALE-PLE 0.06; eyes group AME-PME 0.46; AME-AME 0.24; PME-PME 0.36. Clypeus 0.72 high.

Epigyne: wider than long, with broadly oval CO (Fig. 13E,F).

Variation: females bigger than males; colour pattern of the females are sometimes with more chevrons.

DISTRIBUTION. Queensland, Wet Tropics blocks 2 and 4 (Fig. 31B). Known from many locations on the western and eastern edges of the Carbine Tableland and from the mountains west of Cape Tribulation. Rainforest.

Tropasteron julatten sp. nov.
(Figs 5I, 14, 30B)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Black Mt, NE Qld, 17km ESE Julatten, 800-1000m, rainforest, 16°39'S, 145°29'E, 29-30 Apr 1982, GM, M. Yeates, DC, (QM S4287). PARATYPES: NE Qld: 1♂, Baldy Mt Rd, SW Atherton, 1150m, rainforest, 17°16'S, 145°25'E, 9 Dec 1988, GM, GT, sieved litter (QM S25813); 1♂, Lake Eacham, 750m, 17°17'S, 145°38'E, 9 Dec 1989-14 Jan 1990, GM, GT, HJ, pitfall (QM S25960); 2♀,1♂, Bones Knob, 3km W, 1100m, 17°13'S, 145°25'E, 10 Dec 1995, GM, GT, DC (QM S38213); 17m, Yungaburra, 17°16'S, 145°35'E, 19 Sep 76, R.Mascord (AM KS55636).

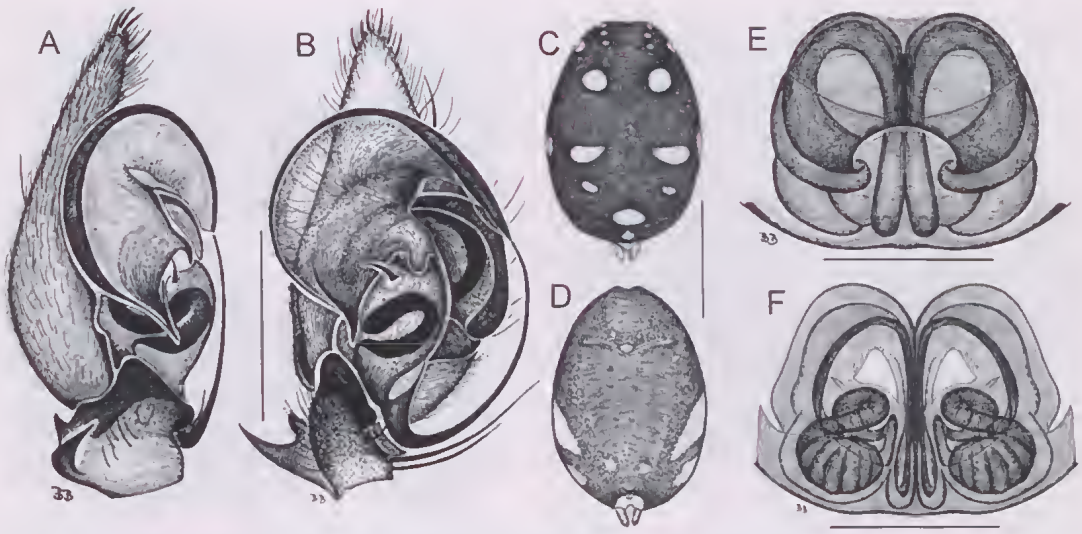

FIG. 15. *Tropasteron luteipes*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

DIAGNOSIS. Similar to *T. eacham* and *T. luteipes* with 2 frontal and 1 small frontal lateral pair of small white dots, but differs from *T. eacham* and *T. luteipes* by short palpal spine (LTA) and pale legs.

DESCRIPTION. *Male* (holotype). Total length 3.76. Ceph 1.76 long, 1.44 wide, 0.72 high; cl/cw 1.22; sternum 0.88 long, 0.84 wide; sl/sw 1.04; abdomen 2.00 long, 1.40 wide.

Colour: carapace yellow; sternum pale to orange brown; chelicerae pale brown, distally dark brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 14C,D) sepia brown; frontally with 2-3 pairs of white dots, and 1 small lateral pair; dorsally with 3 pairs of white patches on top and 1-2 in front of the spinnerets; lateral with 1 elongate horizontal white stripe reaching front; ventrally dark brown. Legs pale to white, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV pale; femur I-IV pale with slightly darker distally.

Eyes: AME smallest; eye group width 0.56 of headwidth; AME 0.07; ALE 0.10; PME 0.10; PLE 0.10; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.30; AME-AME 0.18; PME-PME 0.26. Clypeus 0.40 high.

Male palp (Fig. 14A,B): tegulum (LTA) a short spine, about as wide as long; EP at least twice as long as wide at base (Fig. 5I).

Female (paratype). Total length 3.76. Ceph 1.76 long, 1.44 wide, 0.72 high; cl/cw 1.22; sternum 0.88 long, 0.84 wide; sl/sw 1.04; abdomen 2.00 long, 1.40 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.56 of headwidth; AME 0.07; ALE 0.10; PME 0.10; PLE 0.10; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.30; AME-AME 0.18; PME-PME 0.26. Clypeus 0.40 high.

Epigyne: wider than long, anteriorly wider, with broadly oval CO (Fig. 14E,F).

Variation: white spots in front may come together to a stripe.

DISTRIBUTION. Queensland, Wet Tropics blocks 6, 8 and 9 (Fig. 30B). Known from several areas at the northern end of the Atherton Tableland and from a little further north at Black Mountain. Rainforest.

Tropasteron luteipes sp. nov.
(Figs 5J, 15, 31A)

ETYMOLOGY. Latin *luteipes*, bright yellow legs.

MATERIAL. HOLOTYPE: ♂, Mt Spurgeon, NE Qld, 2.5km S, 1100m, open forest, 16°28'S, 145°12'E, 13-21 Oct 1991, GM, HJ, pitfall (QM S57094). PARATYPES: NE Qld: 1♀,3♂, same data as holotype (QM S25793); 1♀,3♂, as previous (trap 2), 1080m, 16°27'S, 145°11'E, 19 Nov 1997-8 Feb 1998, GM, DC, pitfall (QM S41933); 1♂, as previous (trap 3), 1100m (QM S41931); 2♀,1♂,

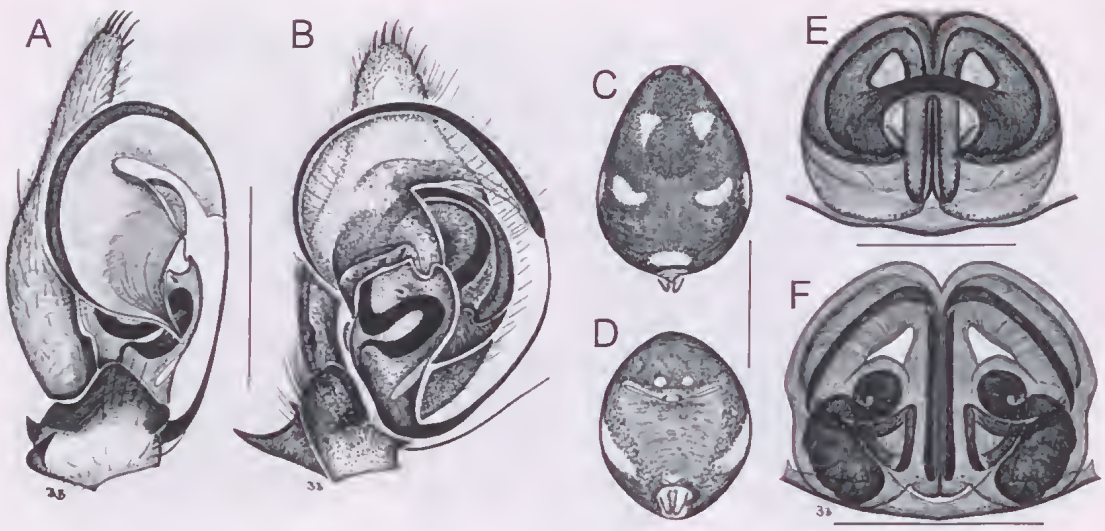

FIG. 16. *Tropasteron malbon*. A,B, palp; A, lateral; B, ventral; seale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; seale 1mm; E,F, epigyne; E, ventral: F, dorsal; seale 0.25mm.

Windsor Tbld, NW, 1180m, open forest, 16°13'S, 144°59'E, 24 Nov 1997-9 Feb 1998, GM, DC, pitfall (QM S41914).

DIAGNOSIS. Similar to *T. eacham* and *T. julatten* with 2 frontal and 1 small frontal lateral pair of small white dots but differs from both by clearly annulated legs and from *T. julatten* by long palpal spine (LTA).

DESCRIPTION. Male (holotype). Total length 4.48. Ceph 2.20 long, 1.64 wide, 1.16 high; cl/ew 1.34; sternum 1.0 long, 0.92 wide; sl/sw 1.08; abdomen 2.28 long, 1.60 wide.

Colour: carapace sepia brown; sternum sepia brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 15C,D) sepia brown; frontally with 3 pairs of small white dots, and 1 small lateral pair; dorsally with 3 pairs of white patches on top and 1-2 in front of the spinnerets; lateral with 3 white patches, first small circular, others long; ventrally dark brown. Legs yellow; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.55 of headwidth; AME 0.09; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.34; AME-AME 0.22; PME-PME 0.32. Clypeus 0.52 high.

Male palp (Fig. 15A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 5J).

Female (paratype). Total length 4.36. Ceph 2.28 long, 1.44 wide, 0.96 high; cl/ew 1.58; sternum 0.96 long, 0.92 wide; sl/sw 1.04; abdomen 2.08 long, 1.28 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.56 of headwidth; AME 0.07; ALE 0.13; PME 0.12; PLE 0.14; AME-AME 0.04; AME-ALE 0.05; PME-PME 0.06; PME-PLE 0.12; ALE-PLE 0.05; eyes group AME-PME 0.36; AME-AME 0.18; PME-PME 0.30. Clypeus 0.52 high.

Epigyne: about as wide as long, with broadly oval CO (Fig. 15E,F).

DISTRIBUTION. Queensland, Wet Tropics blocks 3 and 4 (Fig. 31A). Known only from high altitude eucalypt forests on Windsor Tableland and the adjacent western edge of the Carbine Tableland. Open forest.

Tropasteron malbon sp. nov.
(Figs 5K, 16, 30A)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, North Bell Peak, via Gordonvale, NE Qld, 900m, rainforest, 17°05'S, 145°53'E, 16 Sept 1981, GM, DC (QM S57084). PARATYPES: NE Qld: 1♂, as for holotype (QM S3777); 1♀,3♂, North-South Bell Pk. saddle, Malbon Thompson Ra, 17°07'S, 145°54'E, 20-21 Nov 1990, GM, GT, pitfall (QM S57086); 2♂, North Bell Peak, Malbon Thompson

Ra, 17°07'S, 145°53'E, 20-22 Nov 1990, GM, GT, pitfall (QM S57085); 4♂, as previous, 20 Nov 1990 (QM S25810); 1♂, Bellenden Ker Ra, 0.5km S Cable Tower 7, 500m, rainforest, 17°16'S, 145°51'E, 17-24 Oct 1981, Earthwatch Expedition & Qld Museum (QM S27616); 3♂, as previous, pitfall (QM S27611); 1♂, as previous, 1-7 Nov 1981 (QM S27612); 2♂, as previous (QM S27609).

DIAGNOSIS. With weak scutum but similar in colour pattern and body shape to *T. splendens*, differs in colour pattern by: abdomen frontally with 1 pair of small white spots and different shape of palp, with a very short membranous spine (LTA).

DESCRIPTION. *Male* (holotype). Total length 4. Ceph 2.20 long, 1.60 wide, 1 high; el/ew 1.37; sternum 1.08 long, 0.88 wide; sl/sw 1.22; abdomen 1.80 long, 1.28 wide.

Colour: ceph, sternum orange brown; chelicerae orange; maxillae and labium pale brown, distally white. Abdomen (Fig. 16C,D) sepia brown; frontally with 1 pair of small white dots; dorsally with scutum and 2 pairs of white patches on anterior part and with 2 in front of the spinnerets; lateral with 1 white stripe; ventrally pale brown. Legs pale brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white becoming continuously dark brown distally.

Eyes: AME smallest; eye group width 0.61 of headwidth; AME 0.10; ALE 0.12; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.02; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.24; PME-PME 0.30. Clypeus 0.48 high.

Male palp (Fig. 16A,B): tegulum (LTA) a short spine, about as wide as long; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 5K).

Female (paratype). Total length 5.08. Ceph 2.52 long, 1.68 wide, 1.16 high; el/ew 1.50; sternum 1 long, 0.96 wide; sl/sw 1.04; abdomen 2.56 long, 1.84 wide.

Colour: as in male.

Eyes: AME smallest; AME 0.10; ALE 0.12; PME 0.14; PLE 0.14; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.38; AME-AME 0.24; PME-PME 0.34. Clypeus 0.56 high.

Epigyne: about as wide as long, with semicircular CO (Fig. 16E,F).

Variation: additional to the lateral white stripe there may be a small white dot. Some males also have a dorsal weak abdominal scutum.

DISTRIBUTION. Queensland, Wet Tropics blocks 10 and 11 (Fig. 30A). Known from mid-altitude on the eastern side of the Bellenden Ker Range and from the highest part of the nearby Malbon Thompson Range. Rainforest.

Tropasteron monteithi sp. nov.
(Figs 5L, 17, 31A)

ETYMOLOGY. For Dr Geoff Monteith of the Queensland Museum, collector of the holotype.

MATERIAL. HOLOTYPE: ♂, Mossman Bluff Track, NE Qld, 5-10km W Mossman. Site 4, 800-1100m, rainforest, 16°25'S, 145°2'E, 20 Dec1989-15 Jan 1990, GM, GT, ANZSES Expedition, pitfall (QM S56838). PARATYPES: NE Qld: 5♂, as for holotype (QM S18161); 2♂, as previous (QM S18188): 4♂, as previous (Site 5), 760m, 16°28'S, 145°22'E, 16-30 Dec 1988, pitfall (QM S16646);1♂, as previous, Site 6A, 810m (QM S18154); 2♂, as previous, 600m, 16°39'S, 145°34'E, 16-30 Dec 1988 (QM S18173); 2♂, as previous, 600m, 1-16 Jan 1989, flight intercept trap (QM S18182); 2♂, as previous, Site 5A, 650m, 20 Dec 1989-15 Jan 1990, pitfall (QM S18155); 1♂, as previous, Site 5, 660m, 1-16 Jan 1989, flight intercept trap (QM S18171); 2♂, as previous, 20 Dec 1989-15 Jan 1990, pitfall (QM S18156); 1♀,4♂, as previous, Site 6, 660m, flight intercept trap (QM S18180); 1♂, Mt Lewis Rd, 22km from H'way (Site 3), 1000m, rainforest, 16°35'S, 145°17'E, 18 Dec 1989-13 Jan 1990, GM, GT ANZSES Expedition, pitfall (QM S18181); 1♂, as previous (QM S18160); 1♂, Mt Lewis Rd, 16km from H'way (Site 20), 960m, rainforest, 16°35'S, 145°17'E, 18 Dec 1989-13 Jan 1990, GM, GT ANZSES Expedition, pitfall (QM S18183); 1♂, Mt Demi, 7km SW Mossman, 1100m, 16°30'S, 145°19E , 29 Oct 1983, DY, GT, Berlesate (QM S56839); 2♀,29♂, as previous, 17 Dec 1995-25 Jan 1996, GM, GT, Ford, pitfall (QM S41359); 1♂, as previous (AM KS83921).

DIAGNOSIS. Differs from all other species by abdomen without white spots frontally and with 3 to 4 pairs of white patches on top and 2 to 3 in front of the spinnerets, ventrally with 1 pair of white stripes.

DESCRIPTION. *Male* (holotype). Total length 3.92. Ceph 2.00 long, 1.52 wide, 0.88 high; el/ew 1.31; sternum 0.96 long, 0.92 wide; sl/sw 1.04; abdomen 1.92 long, 1.24 wide.

Colour: carapace, sternum orange brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 17C,D) sepia brown; dorsally with 3 or 4 pairs of white patches on top and 2 or 3 in front of the spinnerets; lateral with 2-3 white stripes; ventrally pale brown; with 1 pair of white stripes and with 1 pair of white patches near ; coxae I-IV

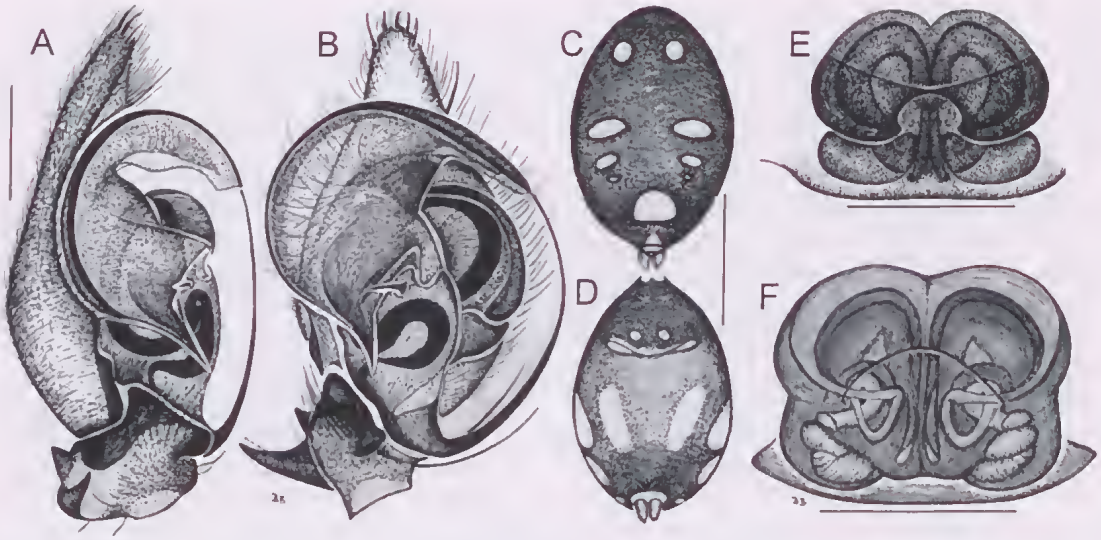

FIG. 17. *Tropasteron monteithi*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown.

Eyes: AME smallest; eye group width 0.50 of headwidth; AME 0.09; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.22; PME-PME 0.32. Clypeus 0.52 high; chilum undivided.

Male palp (Fig. 17A,B): tegulum (LTA) a short spine, about as wide as long; EP at least twice as long as wide at base (Fig. 5L).

Female (paratype). Total length 5.04. Ceph 2.24 long, 1.52 wide, 0.84 high; el/ew 1.47; sternum 0.92 long, 0.92 wide; sl/sw 1; abdomen 2.80 long, 2.08 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.53 of headwidth; AME 0.08; ALE 0.14; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.06; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.36; AME-AME 0.20; PME-PME 0.32. Clypeus 0.60 high.

Epigyne: wider than long, with oval CO (Fig. 17E,F).

Variation: lateral white patches on abdomen sometimes fused with ventral white spots.

DISTRIBUTION. Queensland, Wet Tropics block 4 (Fig. 31A). Restricted to high elevations on the central and eastern Carbine Tableland. Rainforest.

Tropasteron palmerston sp. nov.
(Figs 6A, 18, 30B)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Palmerston NP, NE Qld (NQ 11), 670m, rainforest, 17°35'S, 145°42'E, 30 Nov 1992-15 Apr 1993, RR, PL, pitfall (QM S57091). PARATYPES: NE Qld: 1♂, as for holotype (QM S57090); 1♂, as previous, 30 Oct 1991-24 Jul 1992, RR, PL, MS (QM S24717); 1♂, as previous, 30 Oct 1991-24 Jul 1992, RR, PL, MS (QM S24726); 1♂, as previous, 30 Nov 1992-15 Apr 1993, RR, PL (QM S22947); 10♂, as previous, 25 Jul-30 Nov 1992, RR, PL, MS, pitfall (QM S21932).

DIAGNOSIS. Similar to *T. monteithi* in abdominal colour pattern, but differs in abdomen with 3-4 pairs of white patches on anterior part and 3-4 in front of the spinnerets and male palp without spine (LTA).

DESCRIPTION. *Male* (holotype). Total length 3.16. Ceph 1.64 long, 1.20 wide, 0.72 high; el/ew 1.36; sternum 0.76 long, 0.76 wide; sl/sw 1; abdomen 1.52 long, 1 wide.

Colour: carapace, sternum orange brown; chelicerae orange; maxillae and labium pale brown, distally white. Abdomen (Fig. 18C,D) sepia brown; dorsally with 3-4 pairs of white patches on anterior part and 3-4 in front of the spinnerets; lateral with 1 white stripe; ventrally dark brown; with 1 pair of long white patches.

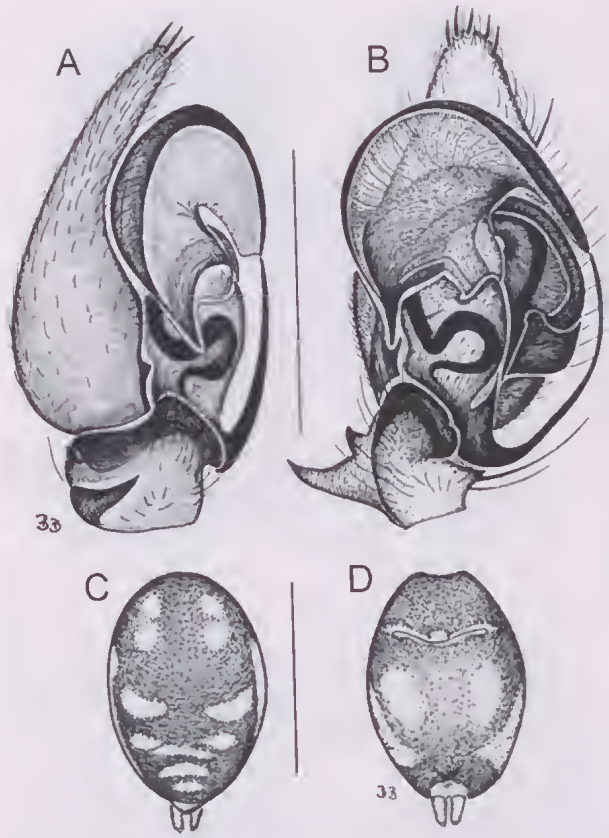

FIG. 18. *Tropasteron palmerston*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm.

Legs pale brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white becoming continuously dark brown distally; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.62 of headwidth; AME 0.08; ALE 0.10; PME 0.10; PLE 0.12; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.28; AME-AME 0.18; PME-PME 0.24. Clypeus 0.30 high.

Male palp (Fig. 18A,B): tegulum (LTA) absent; sperm duct semicircular; EP at least 2 times as long as wide at base (Fig. 6A).

Female unknown.

DISTRIBUTION. Queensland Wet Tropics block 12 (Fig. 30B). Known only from the Palmerston River valley at the southern edge of the Atherton Tableland. Rainforest.

Tropasteron raveni sp. nov.
(Figs 6B, 19, 29B)

ETYMOLOGY. For Dr Robert Raven of the Queensland Museum, in esteem for his important work on Australian spiders.

MATERIAL. HOLOTYPE: ♂, Eungella NP, ME Qld, Finch Hatton Gorge (NQ 37), rainforest, 21°04'E, 148°38'S, 3 Dec 1992-23 Apr 1993, RR, PL, pitfall (QM S56855). PARATYPES: ME Qld: 1♀,17♂, as for holotype (QM S24632); 1♂, as for holotype (AM KS83922); 1♂, as previous, RR, PL, MS (QM S24769); 1♀,9♂, as previous (QM S24780); 1♂, as previous, 9 Nov 1991-28 Jul 1992 (QM S19896); 2♀, Finch Hatton NP, 21°09'S, 148°38'E, 14-Feb-86, RR, JG (QM S9936); 1♀,1♂, Eungella area, eucalypt forest, 21°01'41"S, 148°31'41"E, 20 Apr 1998, RR, JG, pitfall (QM S55633); 1♀,4♂, Upper Hall Ck via Carmila, 21°52'S, 149°18'E, 4 Dec 1996-6 Apr 1997, GM, E. Mulder, pitfall (QM S40602); 1♀,2♂, Mt Hayward, 20°20'S, 148°45'E, 20 Nov 1992-mid Apr 1993, GM, DC, pitfall (QM S41052).

DIAGNOSIS. Differs from most other species by short EP. Abdomen similar to *T. cleveland* with no white spots frontally, but differs by femur I-IV proximal margin brown, medium part white, distal part dark brown.

DESCRIPTION. *Male* (holotype). Total length 3.8. Ceph 2.00 long, 1.40 wide, 0.88 high; el/ew 1.43; sternum 0.92 long, 0.88 wide; sl/sw 1.05; abdomen 1.80 long, 1.36 wide.

Colour: carapace, sternum orange brown; chelicerae orange; maxillae and labium medium brown, distally white. Abdomen (Fig. 19C,D) sepia brown; dorsally with 2 pairs of white patches on top and 2-3 in front of the spinnerets; lateral with 1 white stripe; ventrally pale brown. Legs yellow, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal margin brown, medium part white, distal part dark brown; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.60 of headwidth; AME 0.10; ALE 0.13; PME 0.13; PLE 0.14; AME-AME 0.02; AME-ALE 0.02; PME-PME 0.04; PME-PLE 0.08; ALE-PLE 0.01; eyes group AME-PME 0.30; AME-AME 0.22; PME-PME 0.30. Clypeus 0.44 high.

Male palp (Fig. 19A,B): tegulum (LTA) a short spine, about as wide as long; sperm duct

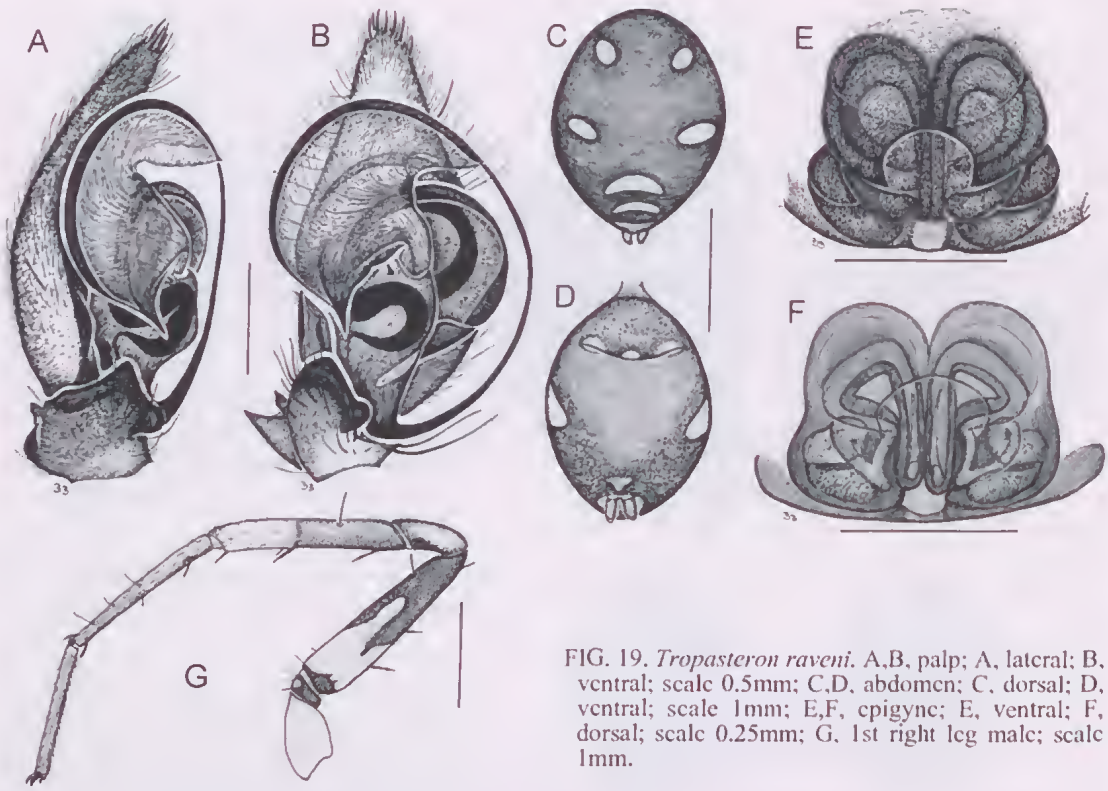

FIG. 19. *Tropasteron raveni*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm; G, 1st right leg male; scale 1mm.

semicircular; EP about as long as wide at base (Fig. 6B).

Female (paratype). Total length 3.76. Ceph 1.96 long, 1.32 wide, 0.84 high; el/ew 1.48; sternum 0.84 long, 0.84 wide; sl/sw 1; abdomen 1.80 long, 1.28 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.56 of headwidth; AME 0.08; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.20; PME-PME 0.30. Clypeus 0.44 high.

Epigyne: about as long as wide, with semicircular CO (Fig. 19E,F).

DISTRIBUTION. Widespread in the central Queensland rainforest system from near Proserpine south through the Eungella Range to the mountains west of Carmila. (Fig. 29B). Rainforest and eucalypt forest.

Tropasteron splendens sp. nov.
(Figs 6C, 20, 31B)

ETYMOLOGY. Latin *splendens*, shining; surface of abdomen and carapace is iridescent.

MATERIAL. HOLOTYPE: ♂, Big Tableland, NE Qld, 700m, 15°43'S, 145°17'E, 20-21 Dec 1990, ANZSES expedition, pitfall (QM S57095). PARATYPES: NE Qld: 10♂, as for holotype (QM S25681); 4♂, Big Tableland, 740m, 15°43'S, 145°17'E, 20 Dec 1990-8 Jan 1991, ANZSES expedition, flight intercept trap (QM S25688); 2♂, Lambs Head, 10km W Edmonton, 1200m, rainforest, 17°02'S, 145°38'E, 13 Dec 1988, GM, GT, Moss (QM S25684); 3♂, Mt Finnigan summit, via Helenvale, 850-950m, 15°49'S, 145°17'E, 3-5 Dec 1990, DC, GT, L. Roberts, pitfall (QM S25686);1♀,3♂, Mt Finnigan summit, via Helenvale, 15°49'S, 145°17'E, 3-5 Dec 1990, pitfall (QM S25693); Davies Creek Road, via Mareeba 750m, 17°02'33"S, 145°36'51"E, 4-13 Dec 1988, GM,GT, pitfall (QM S49365).

DIAGNOSIS. Similar in colour pattern and body shape to *T. malbon*, differs in colour pattern by: abdomen frontally with 2 pair of small white spots; and different shape of palp, with a very long spine (LTA).

DESCRIPTION. *Male* (holotype). Total length 4.32. Ceph 2.24 long, 1.68 wide, 0.88 high; el/ew 1.33; sternum 1.08 long, 1 wide; sl/sw 1.08; abdomen 2.08 long, 1.32 wide.

Colour: carapace, sternum orange brown; chelicerae medium brown; maxillae and labium

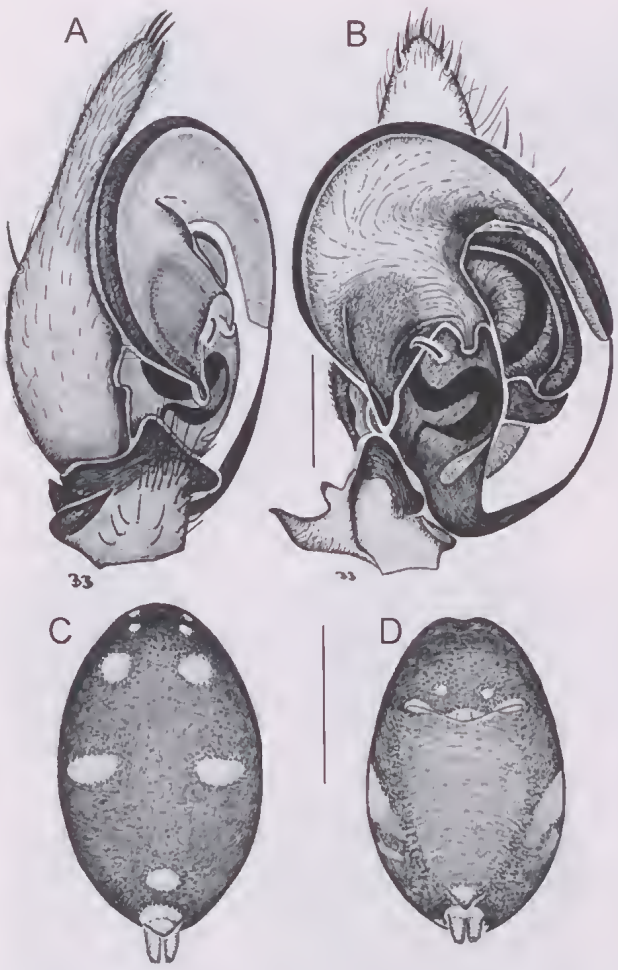

FIG. 20. *Tropasteron splendens*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm.

medium brown, distally white. Abdomen (Fig. 20C,D) sepia brown; frontally with 2 pairs of small white dots; dorsally with or without weak scutum and 2 pairs of white patches on anterior part and with 2 in front of the spinnerets; laterally with 1-2 white stripe a first small, second longer; ventrally dark brown. Legs medium brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white becoming continuously dark brown distally; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.49 of headwidth; AME 0.08; ALE 0.13; PME 0.13; PLE 0.14; AME-AME 0.02; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.18; PME-PME 0.30. Clypeus 0.56 high.

Male palp (Fig. 20A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 6C).

Female unknown.

DISTRIBUTION. Queensland, Wet Tropics blocks 1 and 7 (Fig. 31B). Distribution shows a disjunction of 150km between the mountains at the northern end of the Wet Tropics (Mt Finnigan and Big Tableland) and the Lamb Range, west of Cairns. Rainforest.

Tropasteron thompsoni sp. nov.
(Figs 6D, 21A-F, 30B)

ETYMOLOGY. For Geoff Thompson of the Queensland Museum, a collector of the types.

MATERIAL. HOLOTYPE: ♂, Lambs Head, NE Qld, 10km W Edmonton, 1200m, rainforest, 17°2'S, 145°39'E, 10 Dec 1989-8 Jan 1990, GM, GT, HJ, pitfall (QM S56850). PARATYPES: NE Qld: 1♀,2♂, as for holotype (QM S25962); 1♂, Mt Edith, Lamb Ra, 1140m, rainforest, 17°10'S, 145°37'E, 11 Oct 1982, GM, DY, GT (QM S3780); 1♀,12♂, Mt Formatine South, 700m, 16, 433'S, 145°37'E, 23-24 Nov 1990, GM, GT (QM S25691); 1Y, as previous (AM KS83923); 5♂, Davies Ck Rd, 20km ESE Mareeba, 750m, 17°02'33"S, 145°36'51"E, 4-13 Dec 1988, GM, GT, pitfall (QM S31586); 1♂, Isley Hills, 1050m, 17°03'S, 145°42'E, 30 Nov 93, GM, HJ (QM S25959); 1♂, Mareeba, 22km SE, 900m, rainforest, 17°05'S, 145°36'E, 4 Nov 1983, DY, GT, sieved litter (QM S3802); 1♂, Atherton Tableland, Tinaroo Falls Dam, 17°11'S, 145°34'E, 30 Dec 81, B. & M. Baehr, pitfall (QM S57088); 1♂, Mt Hypipamee NP, The Crater, 15km S Atherton, 17°25'29"S, 145°29'00"E, 29 Dec 81, B. & M. Baehr (QM S57087).

DIAGNOSIS. Differs from all other species by abdomen ventrally with 1 pair of white stripes and 1 white stripe from epigastric fold to near tracheal spiracle. Male palp with long strong spine (LTA).

DESCRIPTION. *Male* (holotype). Total length 4.08. Ceph 2.08 long, 1.56 wide, 1 high; cl/cw 1.33; sternum 1 long, 0.92 wide; sl/sw 1.08; abdomen 2.00 long, 1.48 wide.

Colour: carapace, sternum sepia brown; chelicerae medium brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 21C,D)

sepia brown, iridescent; frontally with 1 pair of small white dots, and 1 small lateral pair; dorsally with 2 pairs of white patches on top and 2-3 in front of the spinnerets; laterally with 3-4 white stripes; ventrally dark brown; with 1 pair of white stripes and 1 white stripe from epigastric fold to near tracheal spiracle. Legs pale brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown; tibia I distally white.

Eyes: AME smallest, PLE largest; eye group width 0.57 of headwidth; AME 0.08; ALE 0.14; PME 0.14; PLE 0.16; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.34; AME-AME 0.20; PME-PME 0.32. Clypeus 0.44 high.

Male palp (Fig. 21A,B): tegulum (LTA) a short spine, as wide as long; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 6D).

Female (paratype). Total length 4.48. Ceph 2.08 long, 1.48 wide, 0.96 high; cl/cw 1.40; sternum 0.92 long, 0.92 wide; sl/sw 1; abdomen 2.40 long, 1.76 wide.

Colour: as in male.

Eyes: AME smallest, or PLE largest; eye group width 0.55 of headwidth; AME 0.08; ALE 0.12; PME 0.12; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.34; AME-AME 0.20; PME-PME 0.28. Clypeus 0.48 high.

Epigyne: wider than long, with semicircular CO (Fig 21E,F).

Variation: ventral white patches on abdomen may be connected.

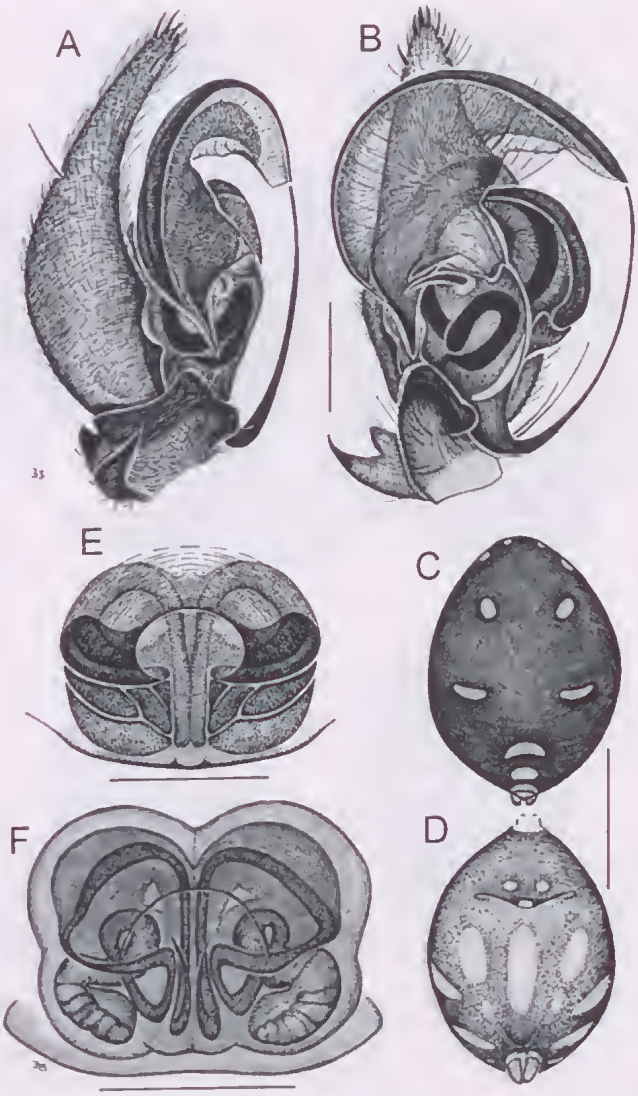

FIG. 21. *Tropasteron thompsoni*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm; E,F, epigyne; E, ventral; F, dorsal; scale 0.25mm.

DISTRIBUTION. Queensland, Wet Tropics blocks 6, 7, 8 and 9 (Fig. 30B). Ranges from Mt Formartine south through the Lamb Range to the northern parts of the Atherton Tableland and Hugh Nelson Range. Rainforest.

Tropasteron tribulation sp. nov.
(Figs 6E, 22, 31A)

ETYMOLOGY. For the type locality, a noun in apposition.

MATERIAL. HOLOTYPE: ♂, Cape Tribulation, NE Qld, 3.5km W (Site 7), 680m, rainforest, 16°05'S, 145°27'E, 2-7 Oct 1982, GM, DY, GT, pyrethrum knockdown (QM S57096). PARATYPES: NE Qld: 1♂, as holotype, 2-7 Oct 1982, GM, DY, GT, pyrethrum knockdown (QM S4288); 1♂, as previous, 23 Sep-7 Oct 1982, pitfall (QM S4283); 1♂, as previous, 2.5km W (Site 5), 180m, 23 Sep-7 Oct 1982, pitfall (QM S4256); 1♀, as previous, 2.7km W (Site 5A), 400m, Jan 83, GM, sieved litter (QM S4269); 1♀, as previous, 1.5km W (Site 3), 150m, 5-9 Jan 1983, baited pitfall (QM S4270); 1♀, as previous, 2.7km W (Site 5A), 400m, 5-9 Jan 1983, baited pitfall (QM S3765); 1♂, as previous, 2km W (Site 4), 200m, 23 Sep-7 Oct 1982, GM, DY, GT, pitfall (QM S4289); 1♂, as previous, transect, site 6, 500m, rainforest, 17 Nov 98, GM, pyrethrum knockdown, trees (QM S47503); 1♂, Fritz Ck, Bloomfield,

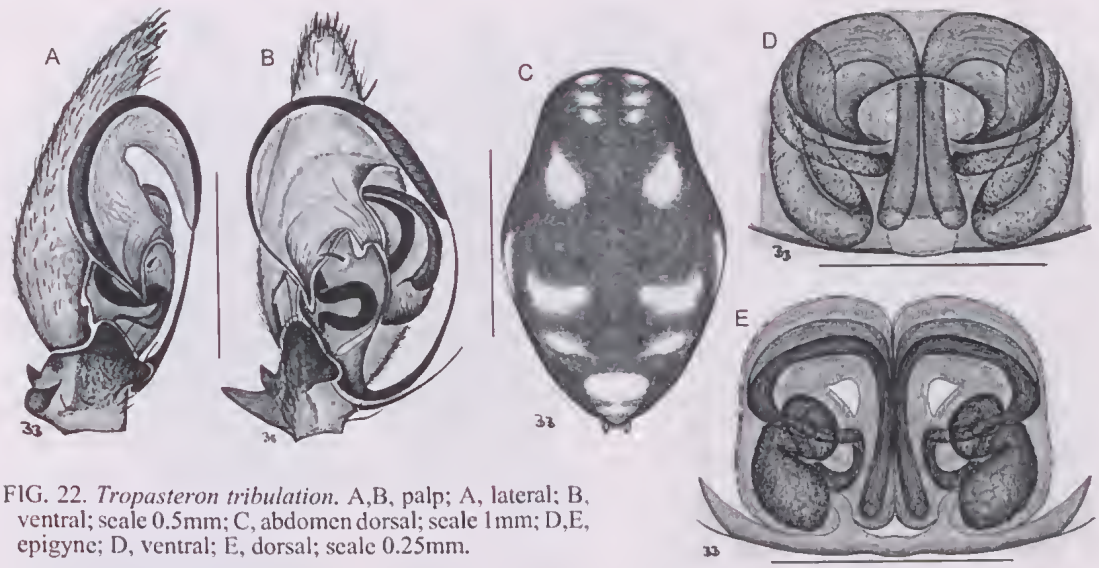

FIG. 22. *Tropasteron tribulation*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C, abdomen dorsal; scale 1mm; D,E, epigyne; D, ventral; E, dorsal; scale 0.25mm.

rainforest, 15°52'S, 145°21'E, 31 Dec 75, M. Gray (AM KS0490); 3♀,1♂, Shiptons Flat, 15°47'33"S, 145°13'51"E, 16-21 Nov 1975, RR,VD, pitfall (QM S4467); 1♀,1♂, as previous (AM KS83924); 1♂, Mt Misery road, Site 1, 730m, 15°53'S, 145°13'E, 6 Dec 1990-17 Jan 1991, ANZSES expedition, pitfall (QM S57089); 1♂, West Claudie R, Iron Ra, 50m, rainforest, 12°45'S, 143°14'E, 3-10 Dec 1985, GM, DC (QM S40844).

DIAGNOSIS. Differs from all other species by abdomen with 3 pairs of frontal and without fronto-lateral white spots. Male palp with long spine (LTA).

DESCRIPTION. *Male* (holotype 2nd measurement). Total length 3.4-3.76. Ceph 1.8-1.92 long, 1.32-1.36 wide, 0.72-0.76 high; cl/ew 1.36-1.41; sternum 0.84-0.92 long, 0.84 wide; sl/sw 1-1.09; abdomen 1.6-1.84 long, 1-1.20 wide.

Colour: carapace orange brown. Sternum pale brown, orange brown; chelicerae pale brown, distally dark brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 22C) sepia brown; frontally with 3 pairs of white dots; dorsally with 3 pairs of white patches on top and 1-2 in front of the spinnerets; laterally with 1-2 white patches first small, second elongate; ventrally pale to dark brown; mottled with white, with 1 pair of white patches near tracheal spiracle. Legs pale brown; coxae I-IV white; trochanter I-IV pale to brown; femur I-IV proximal part white becoming continuously dark brown distally.

Eyes: AME smallest; eye group width 0.53-0.64 of headwidth; AME 0.08-0.09; ALE 0.10; PME 0.1-0.13; PLE 0.11-0.13; AME-AME 0.02-0.04; AME-ALE 0.04; PME-PME 0.04-0.06; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.03-0.32; AME-AME 0.18-0.22; PME-PME 0.26-0.30. Clypeus 0.4-0.44 high.

Male palp (Fig. 22A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct semicircular.

Female (paratype). Total length 3.88-4.08. Ceph 1.88-2.08 long, 1.28-1.36 wide, 0.88-0.96 high; cl/ew 1.46-1.53; sternum 0.84-0.92 long, 0.8-0.92 wide; sl/sw 1-1.05; abdomen 2.00 long, 1.32-1.40 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.53-0.54 of headwidth; AME 0.06-7; ALE 0.1-0.12; PME 0.1-0.11; PLE 0.11-0.14; AME-AME 0.04; AME--ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.04; eyes group AME-PME 0.32; AME-AME 0.16-0.18; PME-PME 0.26-0.28. Clypeus 0.52 high.

Epigyne: wider than long, with broadly oval CO (Fig 22E, F).

DISTRIBUTION. This is the most northerly species of *Tropasteron* (Fig. 31A). It occurs from Iron Range in Cape York Peninsula south to the Bloomfield River (Block 1) and Cape Tribulation (Block 2) at the northern end of the Wet Tropics. It is mostly in lowlands but is found up to 680m, west of Cape Tribulation. Rainforest.

Tropasteron yeatesi sp. nov.
(Figs 6F, 23, 30A)

ETYMOLOGY. For Dr David Yeates of CSIRO Entomology, a collector of the types.

MATERIAL. HOLOTYPE: ♂, Bellenden Ker Ra, NE Qld, Summit, 1560m, rainforest, 17°16'S, 145°52'E, 28 Aug-8 Oct 1991, GM, HJ, pitfall (QM S56995). PARATYPES: NE Qld: 1♀,1♂, same data as holotype (QM S25718); 1♀,1♂, Bellenden Ker Ra, Summit TV Stn, 1560m, 17°16'S, 145°51'E, 29 Sep 81, GM, DC (QM S3732); 2♀,1♂, as previous, 29 Apr-2 May 1983, GM, DY (QM S3757); 1♀,1♂, as previous, 28 Oct 1983, GM, DY, GT (QM S4267); 1♂, Massey Ra 4km W, center of Bellenden Ker, 1250m, 17°16'S, 145°49'E, 9-11 Oct 1991, GM, HJ, DC (QM S25783); 4♀,3♂, Mt Bartle-Frere, summit creek, 1500m, rainforest, 17°23'S, 145°48'S, 24 Sep 81, GM, DC, pitfall (QM S3722); 2♀, as previous, 0.5km N of Sth Peak, 17°24'S, 145°49'E, 6-8 Nov 1981, Earthwatch Expedition (QM S47543); 2♀,2♂, as previous, Sth Peak (QM S47543); 1♀, as previous, Sth Peak, 1400-1500m, rainforest , 17°23'S, 145°49'E, 7-8 Oct 1981, Earthwatch Expedition, berlesate (QM S47543); 1♀,1♂, Massey Ra, 12km S Gordonvale, 1300m, rainforest, 17°16'S, 145°49'E, 2 May 1983, GM, DC, sieved litter (QM S47543); 17♂, Bellenden Ker Ra, Cable Tower 3, 1054m, 17°16'S, 145°51'E, 25-31 Oct 1981, Earthwatch & Qld Museum, pitfall (QM S27890); 1♂, as previous, sieved litter (QM S27888); 1♂, as previous, 1-7 Nov 1981, pitfall (QM S27881); 2♂, as previous, 17-24 Oct 1981 (QM S27886); 8♀,4♂, as previous, Summit TV Stn, 1560m, PILI (QM S27596); 3♀,4♂, as previous, 1-7 Nov 1981 (QM S27589); 1♀,1♂, as previous (AM KS83925); 3♀,7♂, as previous, 17-24 Oct 1981, PILI (QM S27591); 1♂, as previous, 0.5km S of Cable Tower 7, 500m, rainforest (QM S27613); 12♂, as previous, pitfall (QM S27610); 1♀,1♂, as previous, Centre Peak Summit, 1500m, rainforest, 11 Apr 79, GM, sieved litter (QM S27595); 1♀, Bellenden Ker Ra, Summit TV Stn, 1560m, rainforest, 29 Apr-2 May 1983, GM, DY (QM S27593); 1♂, as previous (QM S38519); 2♂, as previous (QM S38538); 1♀,1♂, as previous (QM S38547), 2♂, as previous, 17-Apr-97, GM, E. Russell, sieved litter (QM S31918); 2♀,1♂, as previous, Centre Peak summit, rainforest, 28 Aug 91, GM, HJ, sieved litter (QM S31565); 1♂, as previous, Top Stn, rainforest, 17°16'S, 145°52'E, 17-18 Apr 1997, GM, J. Ovenden, pitfall (QM S40691).

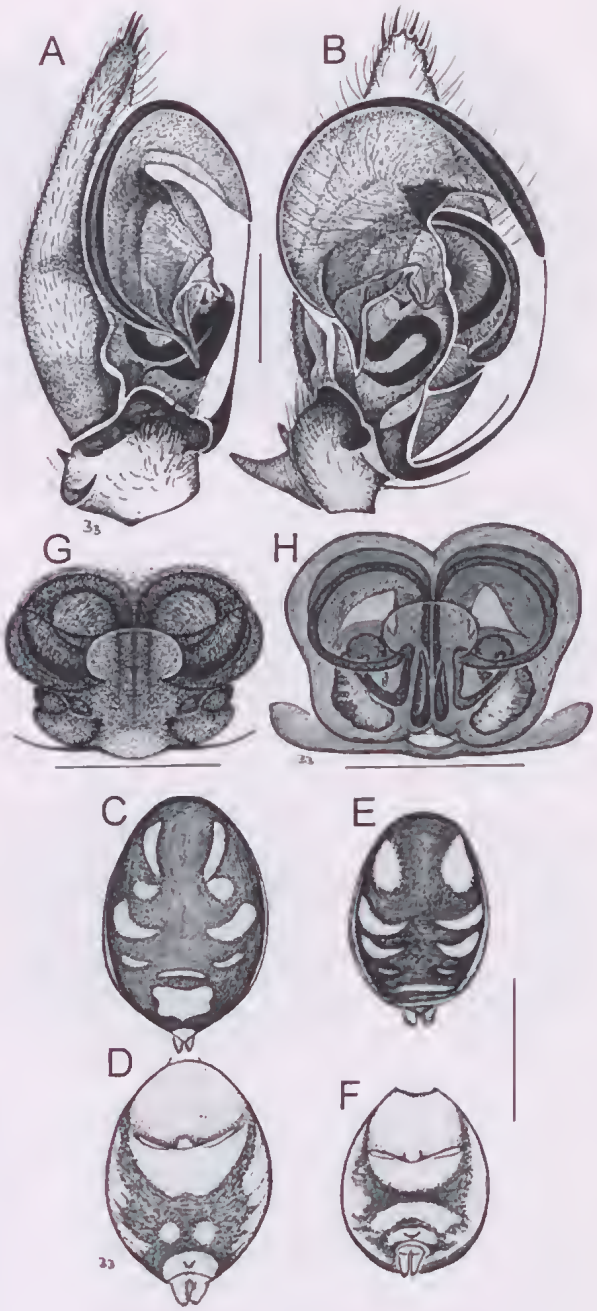

FIG. 23. *Tropasteron yeatesi*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C-F, abdomen variation of colour pattern; C,E, dorsal; D,F, ventral; scale 1mm; G,H, epigyne; G, ventral; H,

DIAGNOSIS. Similar to *T. cooki* but differs from all other species by abdomen without white spots frontally and with 3 to 4 pairs of white patches on top and 3 in front of the spinnerets can be enlarged to white chevrons, ventrally with white chevrons. Male palp with long spine (LTA), at least twice as long as wide.

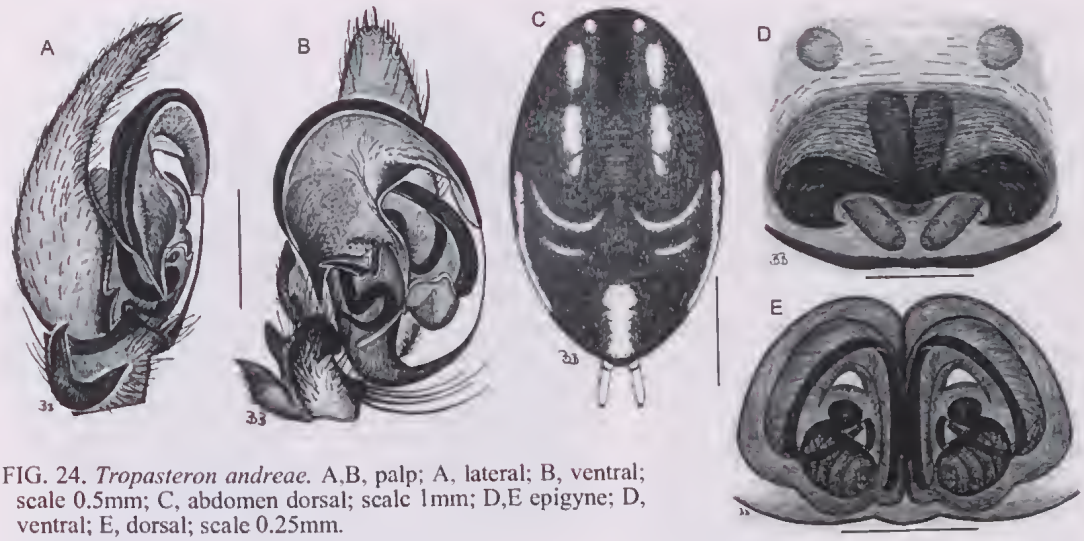

FIG. 24. *Tropasteron andreae.* A,B, palp; A, lateral; B, ventral; scale 0.5mm; C, abdomen dorsal; scale 1mm; D,E epigyne; D, ventral; E, dorsal; scale 0.25mm.

DESCRIPTION. *Male* (holotype). Total length 3.6-4.16. Ceph 2.04-2.24 long, 1.4-1.56 wide, 0.88-0.96 high; cl/cw 1.43-1.45; sternum 0.8-0.96 long, 0.8-0.92 wide; sl/sw 1-1.04; abdomen 1.56-1.92 long, 1.16-1.32 wide.

Colour: carapace, sternum orange brown; chelicerae yellow to medium brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 23C-F) sepia brown; dorsally with 4 pairs of white patches on top and 3 in front of the spinnerets, can be enlarged to white chevrons; laterally with 1 big white patch and pale booklungs; ventrally dark brown; mottled with white. Legs pale brown; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white, distal part dark brown; tibia I-IV proximally and distally with brown spot.

Eyes: AME smallest, PLE largest; eye group width 0.54 of headwidth; AME 0.08; ALE 0.12; PME 0.11-0.13; PLE 0.12-0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.08-0.10; ALE-PLE 0.04; eyes group AME-PME 0.3-0.34; AME-AME 0.20; PME-PME 0.26-0.30. Clypeus 0.44 high; chilum divided.

Male palp (Fig. 23A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted U-shaped; EP at least twice as long as wide at base (Fig. 6F).

Female (paratype). Total length 3.96-4.16. Ceph 1.96-2.20 long, 1.36-1.52 wide, 1-1.08 high; cl/cw 1.44-1.44; sternum 0.84-0.92 long, 0.84-0.92 wide; sl/sw 1-1; abdomen 1.96-2 long, 1.44-1.48 wide.

Colour: as in male.

Eyes: AME smallest, or PLE largest; eye group width 0.5-0.54 of headwidth; AME 0.07-0.08; ALE 0.1-0.12; PME 0.11-0.12; PLE 0.11-0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.04; PME-PLE 0.1-0.14; ALE-PLE 0.04; eyes group AME-PME 0.32-0.34; AME-AME 0.18-0.20; PME-PME 0.26-0.28. Clypeus 0.44-0.48 high.

Epigyne: wider than long, anteriorly wider, with flattened broadly oval CO (Fig. 23G,H).

Variation: The abdominal white patches can fuse to white chevrons.

DISTRIBUTION. Queensland, Wet Tropics block 10 (Fig. 30A). Known only from the contiguous massifs of Bellenden Ker, Bartle Frere and the Massey Range. Almost all specimens are from above 1000m and it is common at the maximum altitudes of 1500-1600m. Rainforest.

KEY TO SPECIES OF *T. ANDREAE*-GROUP

1. Palp dorsal tibial apophysis EP without basal bump. Abdomen with 1 elongate lateral white stripe not reaching front, abdomen, epigyne (Figs 6G, 24A-E) . . . . . *T. andreae*

   Palp dorsal tibial apophysis EP with basal bump. Abdomen with 1 elongate lateral white stripe reaching front (Fig. 6H-J) 2
2. Abdomen dorsally with 1 pair of long stripes (Figs 25C, 26C) 3

   Abdomen dorsally with 2 pairs of long stripes, abdomen, palp (Figs 6J, 27A-C) . . . . . *T. robertsi*
3. Abdomen additional with 2 pairs of dorsal horizontal stripes, abdomen, palp (Figs 6H, 25A-D) . . *T. magnum*

   Abdomen additional with 3 pairs of dorsal horizontal stripes, abdomen, palp (Figs 6I, 26A-D) . . . . . *T. pseudomagnum*

Tropasteron andreae sp. nov.
(Figs 6G, 24, 32)

ETYMOLOGY. For my friend and personal PR consultant Andrea Hammond.

MATERIAL. HOLOTYPE: ♂, Finch Hatton NP, ME Qld, 350m, rainforest, on foliage, 21°09'S, 148°38'E, 7-14 Apr 1975, VD, R. Kohout (QM S57985). PARATYPES: ME Qld: 1♀, same data as holotype (QM S16742); 1♀, as previous, 14-Feb-86, RR, JG (QM S9936).

DIAGNOSIS. The largest species of the genus, differs from all other species in *T. andreae*-group in abdominal pattern and male palp with long strong spine (LTA).

DESCRIPTION. *Male* (holotype). Total length 5.6. Ceph 2.80 long, 2.08 wide, 1.04 high; cl/ew 1.34; sternum 1.20 long, 1.16 wide; sl/sw 1.03; abdomen 2.80 long, 1.80 wide.

Colour: carapace orange brown, iridescent. Sternum orange brown; chelicerae medium brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 24A, B) sepia brown, iridescent; frontally with 1 pair of small white dots; dorsally with 3-4 pairs of white patches, 1, 2 elongated stripes, 3 sometimes 4 horizontal half-moon-shaped and 1 elongate in front of the spinnerets; lateral with 1 white stripe; ventrally dark brown, iridescent. Legs medium brown, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV brown; femur I-IV proximal part white becoming continuously dark brown distally; tibia I-IV proximally pale, distally brown.

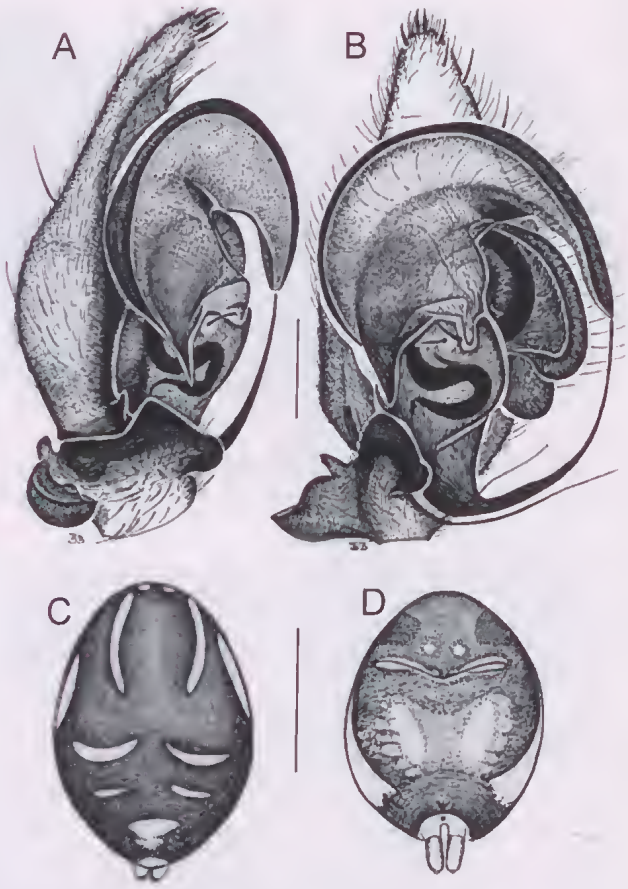

FIG. 25. *Tropasteron magnum*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm.

Eyes: in 2 rows with 4 eyes, both rows procurved; AME smallest; eye group width 0.59 of headwidth; AME 0.10; ALE 0.12; PME 0.14; PLE 0.14; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.08; PME-PLE 0.08; ALE-PLE 0.04; eyes group AME-PME 0.38; AME-AME 0.24; PME-PME 0.36. Clypeus 0.68 high.

Male palp (Fig. 24A, B): cymbium flange short straight, with distal hook, only about 10% of cymbium long, and with small rounded extension, incision in between; tegulum (LTA) a long spine, at least twice as long as wide; DTA membranous, semicircular, distal part folded containing embolus; prolateral extension (PE) short not longer then base of DTA; retrolaterally with sharp tip and without any additional extension; sperm duct inverted Ú-shaped; embolus thin, semicircular, embolus base cylindrical; tibia short; ventro-lateral tibial apophysis with chitinous rim dorsally; EP distally flattened (Fig. 6G). Femur with 2 strong spines dorsally.

Female (paratype). Total length 7.04. Ceph 3.44 long, 2.32 wide, 1.28 high; cl/ew 1.48; sternum 1.44 long, 1.40 wide; sl/sw 1.03; abdomen 3.60 long, 2.80 wide.

Colour: as in male.

Eyes: AME smallest; eye group width 0.56 of headwidth; AME 0.14; ALE 0.16; PME 0.18; PLE 0.20; AME-AME 0.02; AME-ALE 0.06; PME-PME 0.08; PME-PLE 0.18; ALE-PLE 0.06; eyes group AME-PME 0.48; AME-AME 0.30; PME-PME 0.44. Clypeus 0.88 high.

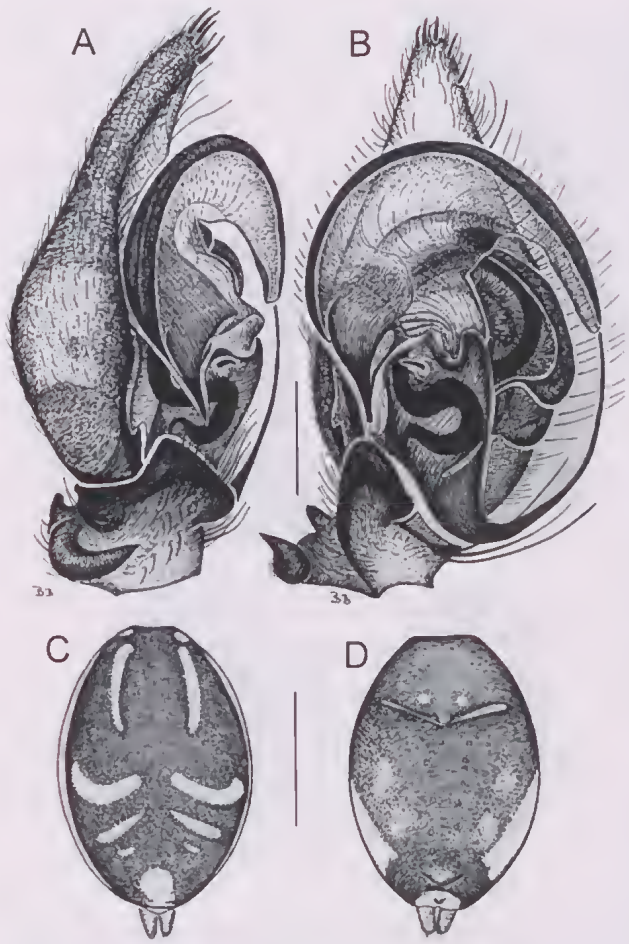

FIG. 26. *Tropasteron pseudomagnum*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm.

Epigyne: much wider than long, with broadly lyriform CO (Fig. 24D,E). Female palpal claw strong with more then 6 teeth.

Variation: in one specimen the 4th horizontal patch on abdomen is reduced.

DISTRIBUTION. Known only from Finch Gatton Gorge within Eungella National Park (Fig. 32). Rainforest.

Tropasteron magnum sp. nov.
(Figs 6H, 25A-D, 32)

ETYMOLOGY. Latin *magnum*, large. *T. magnum* is one of the largest spiders in this genus.

MATERIAL. HOLOTYPE: ♂, Cape Tribulation, NE Qld, 3km W (Site 6), 500m, rainforest, 16°05'S, 145°27'E, 5-9 Jan 1983, GM, baited pitfall (QM S4264).

DIAGNOSIS. Differs from *T. pseudomagnum* and *T. robertsi* in abdomen with 3 pairs of white patches, first elongated, 2, 3 horizontal and 2 in front of the spinnerets.

DESCRIPTION. *Male* (holotype). Total length 4.6. Ceph 2.40 long, 1.96 wide, 0.88 high; cl/ew 1.22; sternum 1.20 long, 1 wide; sl/sw 1.20; abdomen 2.20 long, 1.56 wide.

Colour: carapace pale brown. Sternum orange brown; chelicerae pale brown, distally dark brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 25C,D) sepia brown; frontally with 1 pair of small white dots; dorsally with 3 pairs of white stripes, first long, 2, 3 horizontal and 2 in front of the spinnerets; lateral with 1 white stripe reaching front; ventrally dark brown; with 1 pair of elongate white patches. Legs pale brown, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV white; femur I-IV pale with brown ring distally.

Eyes: AME smallest; eye group width 0.46 of headwidth; AME 0.07; ALE 0.12; PME 0.12; PLE 0.12; AME-AME 0.05; AME-ALE 0.06; PME-PME 0.08; PME-PLE 0.14; ALE-PLE 0.06; eyes group AME-PME 0.36; AME-AME 0.19; PME-PME 0.32. Clypeus 0.64 high.

Male palp (Fig. 25A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct inverted, U-shaped; EP distally flattened (Fig. 6H).

DISTRIBUTION. Queensland, Wet Tropics block 2 (Fig.32). Known only from a single collection at mid-altitude on the mountain slopes west of Cape Tribulation. Rainforest.

Tropasteron pseudomagnum sp. nov.
(Figs 6H, 26, 32)

ETYMOLOGY. For its similarity to *T. magnum*.

MATERIAL. HOLOTYPE: ♂, Mt Spurgeon, NE Qld, 7km N of (camp 2), 1250m, 15°28'18"S, 145°13'18"E, 17-19 Oct 1991, GM, DC, L. Roberts, pitfall (QM S57098). PARATYPES: NE Qld: 2♂, same data as

holotype (QM S25798); 1 ♂, same locality, GM, HJ (QM S25805).

DIAGNOSIS. Differs from *T. magnum* and *T. robertsi* in abdomen with 4 pairs of white patches, first long, 2-4 horizontal and I in front of the spinnerets.

DESCRIPTION. *Male* (holotype). Total length 4.6. Ceph 2.40 long, 1.84 wide, 1 high; cl/cw 1.30; sternum 1.04 long, I wide; sl/sw 1.04; abdomen 2.20 long, 1.52 wide.

Colour: carapace pale brown. Sternum sepia brown; chelicerae pale brown, distally dark brown; maxillae and labium pale brown, distally white. Abdomen (Fig. 26C,D) sepia brown; frontally with 1 pair of small white dots; dorsally with 4 pairs of white patches, first long, 2-4 horizontal and I in front of the spinnerets; lateral with 1 white stripe reaching front; ventrally dark brown; with I-2 pairs of elongate white patches. Legs medium brown, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV white; femur I-IV pale with brown ring distally.

Eyes: AME smallest; eye group width 0.55 of headwidth; AME 0.09; ALE 0.11; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.12; ALE-PLE 0.04; eyes group AME-PME 0.34; AME-AME 0.22; PME-PME 0.30. Clypeus 0.64 high.

Male palp (Fig. 26A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct semicircular; EP distally flattened (Fig. 6H).

DISTRIBUTION. Queensland, Wet Tropics block 4 (Fig. 32). Known only from high altitude on the remote northwest sector of the Carbine Tableland. Rainforest.

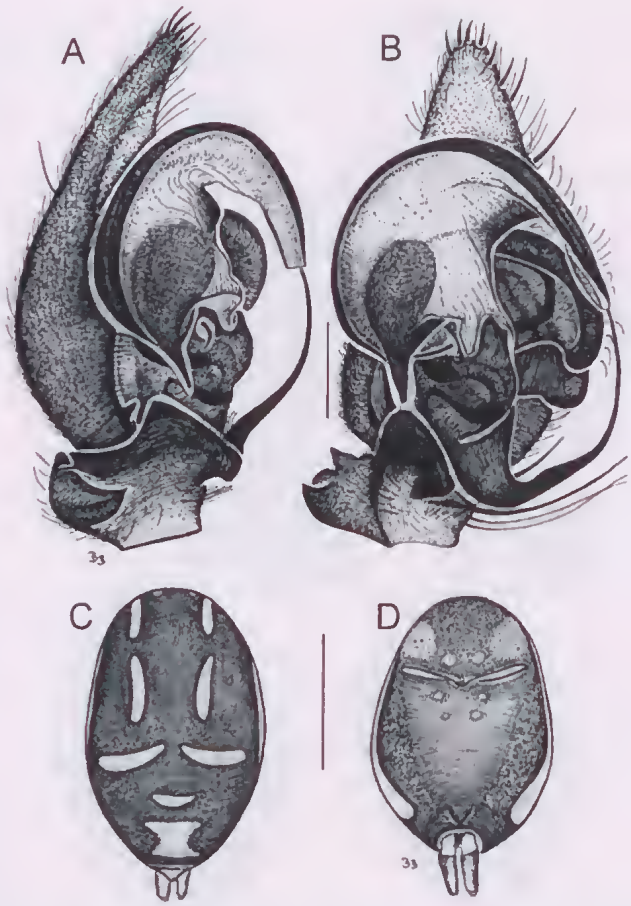

FIG. 27. *Tropasteron robertsi*. A,B, palp; A, lateral; B, ventral; scale 0.5mm; C,D, abdomen; C, dorsal; D, ventral; scale 1mm.

Tropasteron robertsi sp. nov.
(Figs 6J, 27, 32)

ETYMOLOGY. For Lewis Roberts, one of the collectors of the types.

MATERIAL. HOLOTYPE: ♂, Mt Finnigan, NE Qld, 1100m, rainforest, 15°49'S, 145°17'E, 28-30 Nov 1985, GM, DC, L. Roberts (QM S3799). PARATYPES: NE Qld: 1 ♂, same locality, 27 Sep 1975, RR (QM S4470).

DIAGNOSIS. Differs from *T. magnum* and *T. pseudomagnum* in abdomen with 3 pairs of white patches, 1, 2 long stripes, third horizontal and 3 in front of the spinnerets.

DESCRIPTION. *Male* (holotype). Total length 4.68. Ceph 2.36 long, 1.80 wide, 1 high; cl/cw 1.31; sternum 1.04 long, 1 wide; sl/sw 1.04; abdomen 2.32 long, 1.48 wide.

Colour: carapace pale brown. Sternum sepia brown; chelicerae pale brown, distally dark brown; maxillae and labium medium brown, distally white. Abdomen (Fig. 27C,D) sepia brown; frontally with 1 pair of small white dots; dorsally with 3 pairs of white patches, 1, 2 long stripes, third horizontal and 3 in front of the spinnerets; lateral with 1 white stripe reaching front; ventrally dark brown. Legs medium brown, with darker brown lateral stripes; coxae I-IV white; trochanter I-IV white; femur I-IV pale with brown ring distally.

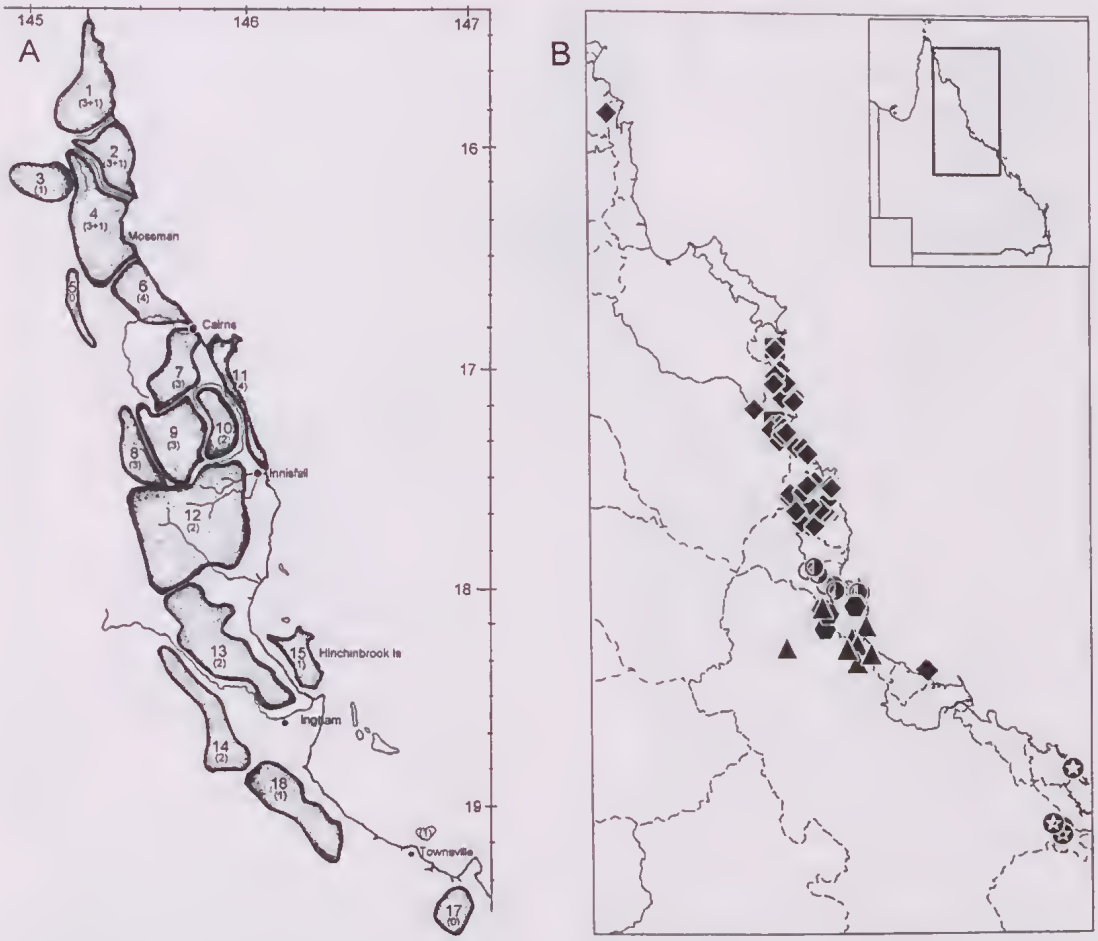

FIG. 28. Maps of the northern Queensland Wet Tropics. A, limits of the 17 mountain/rainforest blocks according to Monteith (1995), modified in Bouchard (2002): 1, Mount Finnigan; 2, Thornton Peak; 3, Windsor Tableland; 4, Carbine Tableland; 5, Hann Tableland; 6, Black Mountain; 7, Lamb Range; 8, Walsh/Hugh Nelson Ranges; 9, Atherton Tableland; 10, Mount Bellenden Ker; 11, Malbon Thompson Range; 12, Walter Hill Range; 13, Kirrama/Cardwell Ranges; 14, Seaview Range; 15, Hinchinbrook Island; 16, Paluma/Blue Water Ranges; 17, Mount Elliot. In brackets, number of species occuring in the rainforest block. B, distribution range of *Tropasteron* spp.

Eyes: AME smallest; eye group width 0.46 of headwidth; AME 0.08; ALE 0.10; PME 0.12; PLE 0.12; AME-AME 0.04; AME-ALE 0.04; PME-PME 0.06; PME-PLE 0.10; ALE-PLE 0.06; eyes group AME-PME 0.34; AME-AME 0.20; PME-PME 0.30. Clypeus 0.60 high.

Male palp (Fig. 27A,B): tegulum (LTA) a long spine, at least twice as long as wide; sperm duct semicircular; EP distally flattened (Fig. 6J).

DISTRIBUTION. Queensland, Wet Tropics block 1 (Fig. 32). Restricted to the summit plateau of Mt Finnigan. Rainforest.

DISCUSSION

With 22 species, *Tropasteron* is one of the largest genera in the *Asteron*-complex and the only one that has radiated in rainforests (Fig. 28B). Most species of *Tropasteron* are found only in montane rainforests; however, *T. cleveland*, *T. fox* and *T. raveni* are also found in adjacent open forest, and *T. luteipes* have been found only in the open forest, at Mt Spurgeon. (ca. 1100m) surrounded by rainforest.

PHYLOGENETIC RELATIONS. All species of *Tropasteron* are closely related in their uniform

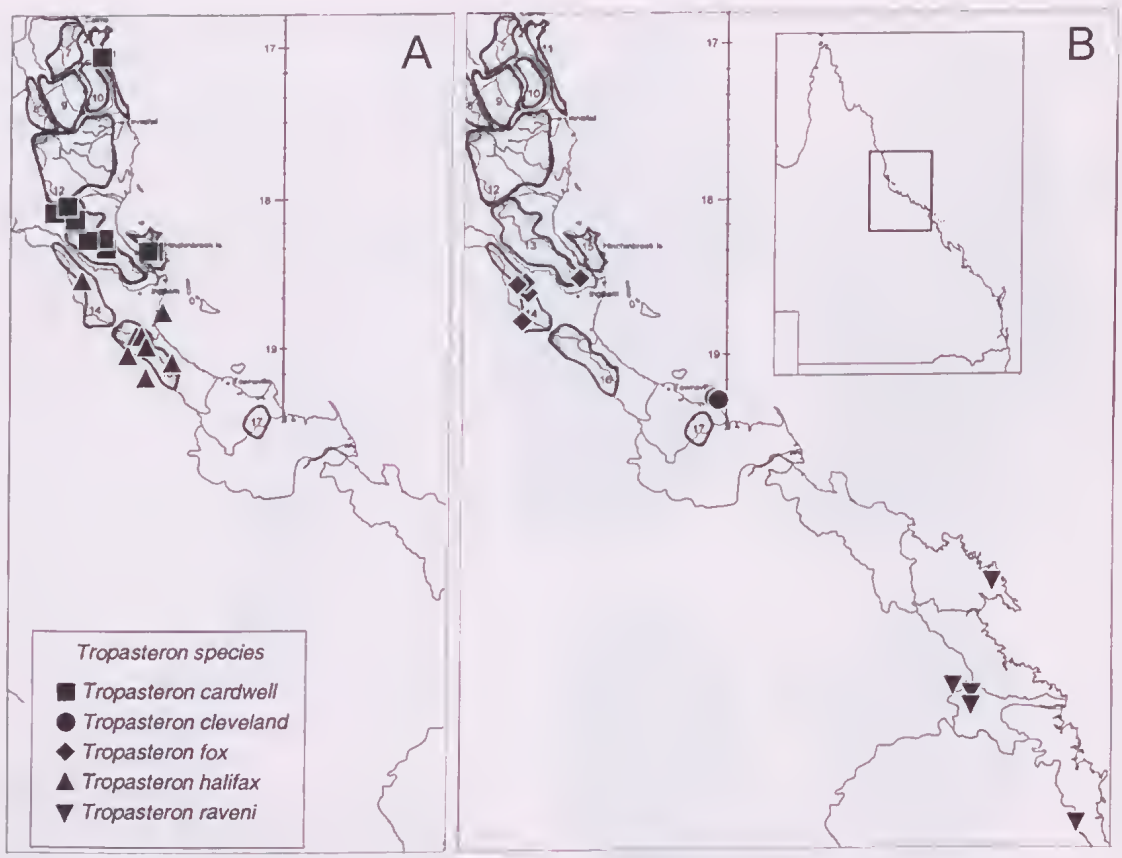

FIG. 29. Distribution of *Tropasteron* species A, *T. cardwell*, *T. halifax*; B, *T. cleveland*, *T. fox*, *T.raveni*.

palps and epigynes but distinct from all other genera of the *Asteron*-complex by their synapomorphies, mentioned in Table 1 (2, 6, 8, 9, 10, 11, 12, 13). Hence, it is difficult to find phylogenetic relationships within the separate species-groups, because parallel evolution obviously took place when ancient aridity events caused the loss of forest corridors connecting each block (Reid & Storey, 2000). Therefore, a complete phylogenetic analysis cannot be done. Nevertheless, there are quite a few character states (Table 1), which help to reconstruct some phylogenetic relations. Two quite distinct species-groups — *T. cleveland*-group and *T. andreae*-group — have evolved.

The combination of the most plesiomorphic characters:

(1) abdomen with 2 pairs of white dots on top and 1-3 dots in front of the spinnerets (Figs 1A, 12C, 19C), as it is found also in the outgroup *Pentasteron* and some other genera of the *Asteron*-complex e.g. in *Asteron*, *Leptasteron*.

(3) male palp with a short external prong of dorsal tibial apophysis (EP) (Figs 5A,D,F, 6B), occur only in 2 (*T. cleveland*, *T. raveni*) of 18 species in *T. cleveland*-group. All 16 other species have longer EP or a more evolved colour pattern with additional white dots.

T. andreae-group seems to be the more apomorphic group, because of **(7)** the more evolved cymbial flange with hook CH (Fig. 24A), **(4)** the dorsal tibial apophysis with EP distally flattened (Fig. 6G-J) and **(12)** the lyriform copulatory opening (CO) (Fig. 24D). *T. andreae* sp. nov. **(5)** without any basal bump (BB) on the external prong of the dorsal tibial apophysis seems to be the most plesiomorphic species in the *T. andreae*-group. All other more evolved species possess this basal bump.

Final phylogenetical results cannot be discussed here because the knowledge of relationships from all genera in the *Asteron*-complex are not yet known.

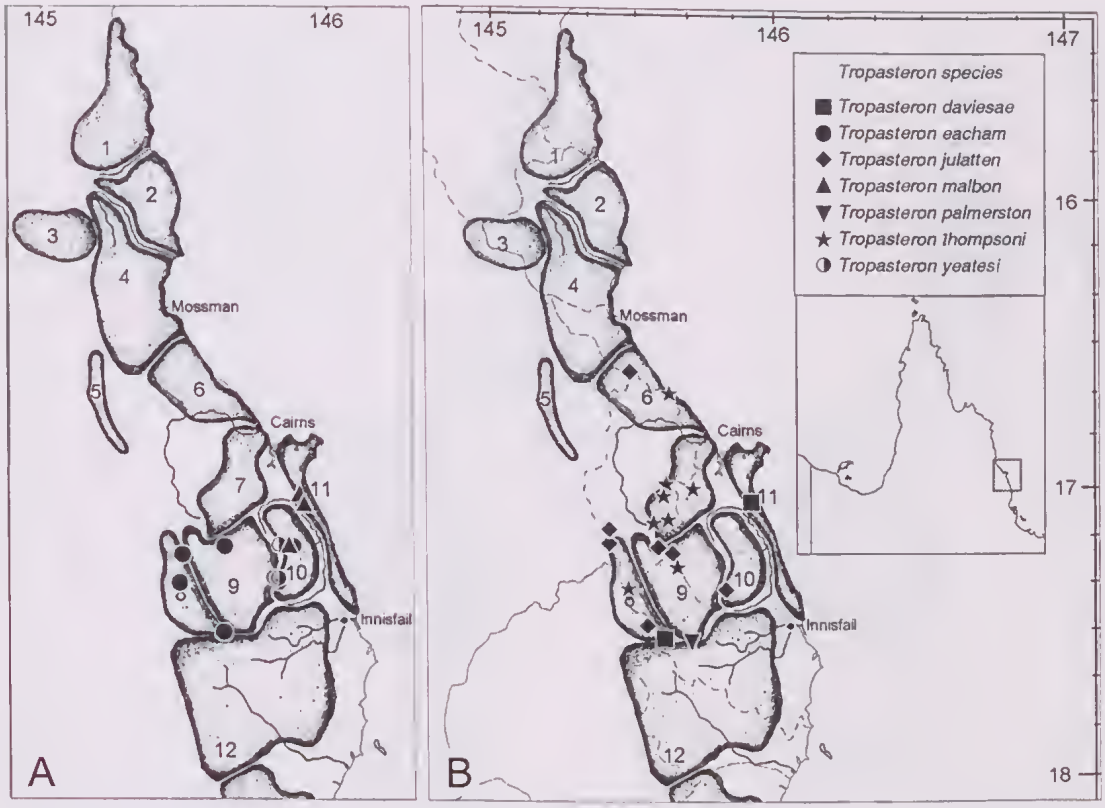

FIG. 30. Distribution of *Tropasteron* species A, *T. eacham*, *T. malbon*, *T. yeatesi*; *B*, *T. daviesae*, *T. julatten*, *T. palmerston*, *T. thompsoni*.

DISTRIBUTION AND BIOGEOGRAPHY

Methods used for collecting *Tropasteron* specimens were similar (pitfall trapping and hand collecting) and sampling effort has been effectively uniform across all sites. Hence, gaps or absences are taken here to be real and not simply an indication of heterogeneous sampling. Based on the examined material of *Tropasteron*, the following conclusions can be made.

All species of the *T. andreae*-group are highly endemic to single localities (Table 2). They are allopatric on the three northern massifs and include a southern outlier at Eungella (*T. andreae*). Their main centre of diversity is in the most northern rainforest blocks: **1** Mt Finnigan (*T. robertsi*), **2** Thornton Peak (*T. magnum*), **4** Carbine Tableland (*T. pseudomagnum*). At all these sites, species of the *T. andreae*-group are sympatric with those of the *T. cleveland*-group.

The much bigger and more diverse *T. cleveland*-group, with 18 species, occurs from Iron Range with its centre in Wet Tropics and also a southern outlier at Carmila (*T. raveni*). Of the other two species that occur outside the WTWHA, most material of *T. tribulation* is from Cape Tribulation and Shiptons Flat with a northern outlier from Iron Range (1 ♂) and the southern *T. cleveland* to which mountain it is endemic both in areas of rainforest and open forest at Cape Cleveland. None of the species at the limits of the genus distribution are sympatric with any other species. As in other examined taxa with low vagility (e.g. beetles: Baehr, 1995; Bouchard, 2002; Reid & Storey, 2000) the main centre of diversity of *T. cleveland*-group is in the northern part of the mountain/rainforest blocks of North Queensland (defined by Monteith, 1995), with 2-4 species in each block: **14** (Seaview Ra.: *T. halifax*, *T. fox*), **13** (Cardwell Ra.: *T. fox*, *T. cardwell*), **12** (Walter Hill Ra.: *T. daviesae*, *T. palmerston*), **11** (Malbon Thompson Ra.: *T. cardwell*, *T. cooki*, *T. malbon*), **10** (Mt Bellenden Ker: *T. yeates*, *T. malbon*), **9** (Atherton Tableland: *T. eacham*, *T. julatten*, *T. thompsoni*), **8**

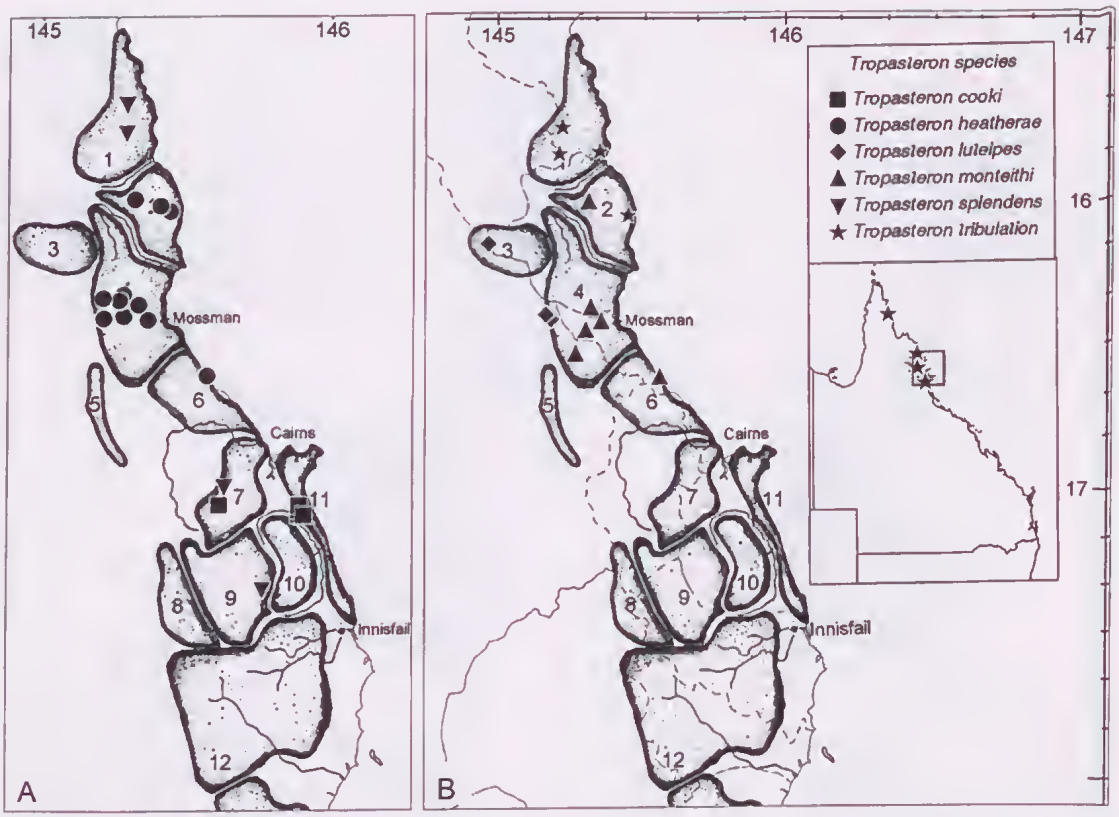

FIG. 31. Distribution of *Tropasteron* species A, *T. luteipes*, *T. monteithi*, *T. tribulation*; *B*, *T cooki*, *T. haetherae*, *T. splendens*.

(Walsh/Hugh Nelson Ranges: *T. eacham*, *T. julattern*, *T. thompsoni*0), 7 (Lamb Ra.: *T. cooki*, *T. splendens*, *T. thompsoni*), **6** (Black Mt: *T. julatten*, *T. thompsoni*), **4** (Carbine Tableland: *T. heatherae*, *T. monteithi*, *T. luteipes*), **2** (Thornton Peak: *T. heatherae*, *T. tribulation*), **1** (Mt Finnigan: *T. heatherae*, *T. splendens*, *T. tribulation*).

Margin rainforest blocks have only 1 or no species **17** (Mt Elliot 0), **16** (Paluma Ra.: *T.*

TABLE 1. Character states and their phylogenetical value in *Tropasteron*.

	Character	Plesiomorphic	Apomorphic
1	Abdominal pattern	2 pairs of white spots	with additional frontal and dorsal pairs
2	DtiA	roughly triangular	with 2 sharp tips (1P, EP)
3	DtiA external prong EP	short, about as long as wide	long, at least twice as long as wide
4	DtiA, EP, tip	sharp	distally flattened
5	DtiA, EP, basally	without bump	with basal bump
6	Cymbium retrolaterally	with flange	with additional small rounded extension
7	Flange on cymbium	straight	hook-shaped
8	Flange on cymbium	at least 1/3 of cymbium long	10-15% length of cymbium
9	LTA	not separated from tegulum	spine-like separated from tegulum
10	Base of embolus	not separated from tegulum	separated from tegulum, cylindrical
11	DTA	simple, spoon-shaped	semicircular, distally folded with short PE
12	Epigyne CO	inverted u or V-shaped	semicircular, to flat oval or lyriform
13	Epigyne CD	CD short only few loops	elongate with big semicircular distal loops

halifax), **15** (Hinchinbrook I: *T. cardwell*), **5** (Hann Tbld.: 0), **3** (Windsor Tbld.: *T. luteipes*).

In contrast to the above mentioned beetles, only about 40 % of the species (9 species) are endemic to 1 single rainforest block. The distribution ranges of most species are over 2 sometimes 3 adjacent rainforest blocks (Table 2). Hence, the main centre of species diversity is in the northern central part of the rainforest blocks in the Wet Tropics of Northern Queensland. According to their distribution pattern, both *T. andreae*-group and *T. cleveland*-group must have diverged or evolved before Eungella/Carmila and Mt Cleveland — where the most plesiomorphic species, *T. andreae*, *T. cleveland* and *T. raveni*, exist — were isolated from the main rainforest block.

Significantly, sympatric species have divergent abdominal patterns.

Within the WTWHA, synapomorphies could be found only for the *T. andreae* and *T. cleveland* group, but not for groups of species within each species group. All other species differ from each other in small differences in palp (length of LTA, length of EP) and or in colour pattern but no evolutionary pattern is evident. At least within *Tropasteron*, parallel evolution obviously took place, when, as a result of ancient arid incursions, the rainforest blocks split up.

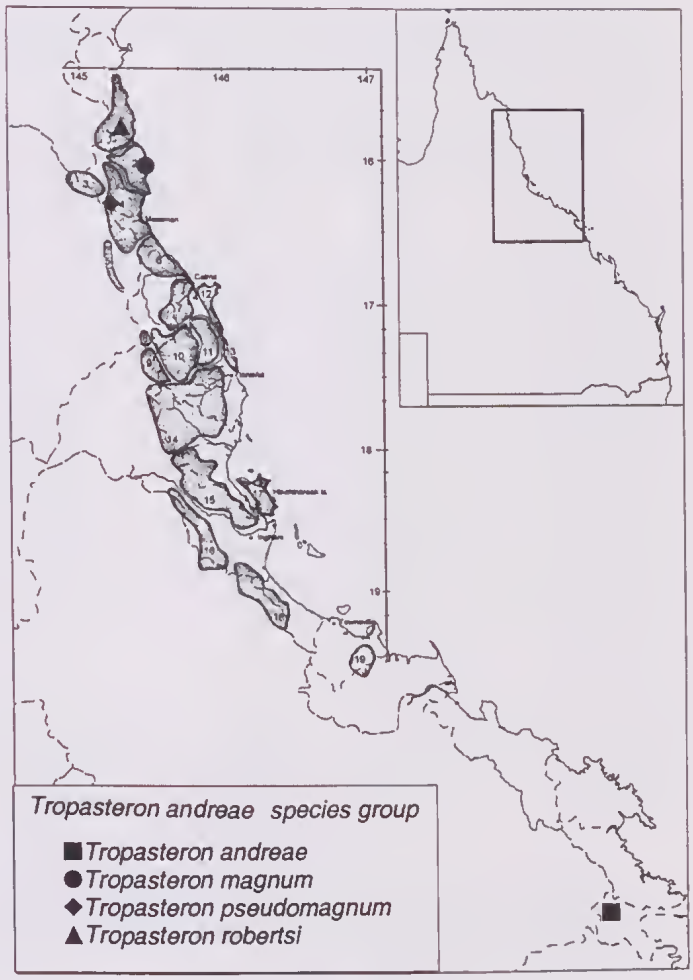

FIG. 32. Distribution of *Tropasteron* species *T. andreae*, *T. magnum*, *T. pseudomagnum*, *T robertsi*.

ACKNOWLEDGEMENTS

I thank Michael Gray and Graham Milledge, Australian Museum (Sydney), Robert Raven and Wendy Hebron, Queensland Museum (Brisbane), for loans of the material and support of the work. For an excellent working atmosphere I thank Valerie Davies, for informative and critical comments Geoff Monteith, for being patient my children Johanna and Ursula Baehr, and for preparing the maps, providing critical comments on the manuscript and help with the scanning electron microscope, Robert Raven. Last, I thank Marshall from the Headlands Chalet (North Stradbroke Island) for providing a wonderful place and spirit for finishing the manuscript. The study is funded by the Australian Biological Resources Study Participatory Program.

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TABLE 2. Distribution of the *Tropasteron* species in the Mountain Rainforest Blocks (Fig. 28A), defined by Monteith (1995) modified in Bouchard (2002). Recorded altitudes are given. Number of examined specimens (in brackets); species in bold occur only at one block. Species are listed from North to South.

Species (specimens)	Altitude	Locality
T. rabertsi (2)	1100m	1
T. tribulation (18)	50-730m	Iron Ra., 1, 2
T. magnum (2)	500m	2
T. pseudamagnum (4)	1250m	4
T. splendens (24)	700-1200m	1, 7
T. heatherae (50)	440-1330m	2, 4
T. luteipes (12)	1100-1180m	3, 4
T. manteithi (63)	600-1100m	4
T. thampsoni (28)	700-1200m	6, 7, 8, 9
T. julatten (36)	750-1100m	6, 8, 9
T. cooki (23)	850-1000m	7, 11
T. eacham (27)	750-1000m	8, 9
T. malban (19)	500-900m	10, 11
T. yeatesi (106)	1054-1560m	10
T. daviesae (22)	800-1000m	12
T. palmerstan (15)	670m	12
T. cardwell (74)	250-800m	11, 13, 15
T. fox (60)	500-650m	13, 14
T. halifax (87)	720-1050m	14, 16
T. cleveland (42)	500-560m	Mt Cleveland
T. raveni (44)	350m	C Qld, Carmila
T. andreae (3)	350m	Eungella NP

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PSYDRINE GROUND BEETLES (COLEOPTERA: CARABIDAE: PSYDRINAE), EXCLUDING AMBLYTELINI, OF EASTERN QUEENSLAND RAINFORESTS

MARTIN BAEHR

Baehr, M. 2003 06 30: Psydrine ground beetles (Coleoptera: Carabidae: Psydrinae), excluding Amblytelini, of eastern Queensland rainforests. *Memoirs of the Queensland Museum* **49**(1): 65-109. Brisbane. ISSN 0079-8835.

The psydrine ground beetles of eastern Queensland, excluding the tribe Amblytelini, are reviewed. Species of *Laccocenus* Sloane, *Teraphis* Castelnau, *Trephisa* Moore, and *Meonis* Castelnau are enumerated, the Queensland species of *Mecyclothorax* Sharp revised, and *Sitaphe* Moore and *Raphetis* Moore fully revised. The following new taxa are described: *Mecyclothorax inflatus* from southern parts of Atherton Tableland, *M. inflatus spinifer* from the Walter Hill Range, *M. impressipennis* from Isley Hills north of Bellenden Ker Range, *M. storeyi frerei* from Bartle Frere, *M. lewisensis uncinatus* from Mt Hemmant and Mt Haleyon north of Thornton Peak, *Sitaphe trapezicollis* from Bellenden Ker/Bartle Frere Ranges, *S. parvicollis* from Bartle Frere Range, *S. minuta* from Lambs Head, Mt Williams, and Isley Hills north of Bellenden Ker Range, *S. hamifera* from Cardwell Range, *S. incurvicollis* from the Walter Hill Range, *S. parallelipennis* from Carbine and Windsor Tablelands, *S. ovipennis* from Thornton Peak, *Raphetis curta* from Springbrook Plateau in southeastern Queensland, and four subspecies of *R. gracilis* Moore, all from northeastern Queensland: *R. g. frerei* from Bellenden Ker/Bartle Frere Ranges and vicinity, *R. g. spinosa* from the surroundings of Mt Lewis, *R. g. spurgeoni* from north of Mt Spurgeon, and *R. g. subarmata* from Mt Spurgeon and Plane Crash Site, the last three subspecies being from different parts of Carbine Tableland.

Within the three revised genera similar patterns of distribution are recognised: all species are montane, and the many extremely similar taxa each occupy single or closely adjacent mountain tops or tablelands. This distribution pattern reflects similar patterns in various invertebrate groups of low vagility occurring in the Wet Tropics of North Queensland. The high level similarity is strong evidence of a rather recent — probably even Pleistocene — allopatric speciation caused by vicariance events due to repeated spreading and retreat of the montane rain forests during the glacial and inter-glacial periods.

Within the strictly northern *Sitaphe*, and also in the *storeyi*-group of *Mecyclothorax*, relationships are still obscure. In *Raphetis* a fairly distinct gradient exists between the plesiotypic southern *R. curta*, the intermediate *R. darlingtoni* from mid-eastern Queensland, and the apotypic *R. gracilis*-complex in north Queensland. ❐ *Coleoptera, Carabidae, Psydrinae, Mecyclothorax, Sitaphe, Raphetis, new species, Australia, Queensland, distribution.*

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By courtesy of Geoff Monteith of Queensland Museum, Brisbane, I received specimens of the psydrine genera *Mecyclothorax* Sharp, *Sitaphe* Moore and *Raphetis* Moore collected during the extensive rain forest sampling program carried out by him and his co-workers on various mountain tops along the east coast of Queensland during the last 20 years. When I requested some voucher specimens of *Raphetis* for comparison during the course of a forthcoming revision of the psydrine tribe Amblytelini, Geoff Monteith asked me to review all specimens because there appeared to be several different — probably undescribed — forms. We agreed, then, that it would be best to combine descriptions of new forms of all genera in a single comprehensive paper to give an overview of the geophile psydrines of the rain forests of eastern Queensland.

This paper, therefore, includes a revision of Queensland *Mecyclothorax*, and complete revisions of *Sitaphe* and *Raphetis*. Other psydrine species that occur near the Queensland/New South Wales border (mostly on Lamington Plateau) are mentioned for completeness. Queensland species of *Meonis* Castelnau, a genus that urgently merits a thorough revision, are mentioned without further commentary.

The tribe Amblytelini is very speciose in eastern Queensland (c. 40 taxa at the present state of knowledge) but is omitted from this paper

because a general revision of that tribe will be printed elsewhere (Baehr, in press a).

More general information about extent, distribution, and phylogeny of the Psydrinae is or will be available from Baehr (1999, in press a). Here I will direct the readers' attention to the use of taxonomic categories higher than genus. I use the term subfamily for the whole psydrine complex, and tribe for such units as Amblytelini, Mecyclothoracini, etc. Other authors rank the tribes as subtribes and the subfamily as a tribe. This is, however, a matter of opinion and is of no serious relevance to the present treatment.

Raphetis and *Sitaphe* were described in Moore's generic revision of the Australian Psydrinae (Moore, 1963) which is still the basis of all work on this group in Australia. In it, Moore described a single species of *Sitaphe* and two species of *Raphetis*, the types of which I have examined. Moore (1984) later described two outstanding species of *Mecyclothorax* from rain forests of North Queensland, and these are reviewed in the present paper.

In tropical Queensland, apart from the tribe Amblytelini, only the three genera that are herein revised occur. Curiously enough, the many mountain tops and tablelands south of Atherton Tableland except for Lamington Plateau and adjacent ranges on the Queensland/New South Wales border, although having been sampled with comparable intensity during the last decade, apparently lack a similarly diverse psydrine fauna. It seems, thus, that except for *Raphetis darlingtoni* Moore at Eungella, west of Mackay, the Psydrinae are almost absent from the many rainforest patches south of the Wet Tropics, and that this absence indicates a real distribution gap.

MATERIAL AND METHODS

Almost all material for this study was collected by Geoff Monteith and his co-workers of the Queensland Museum, Brisbane (QM), and the bulk of the material is in that collection, except for duplicates lodged in the working collection of the author (CBM) in Zoologische Staatssammlung, München. Altogether 542 specimens of *Mecyclothorax* of the *storeyi*-group, 290 specimens of *Sitaphe* and 38 specimens of *Raphetis* were available for this study. In addition, about 80 specimens of southern Queensland species of *Laccocenus*, *Mecyclothorax*, *Trephisa*, *Teraphis* and *Meonis* were noted.

The types of B.P. Moore's species were kindly loaned from the Australian National Insect Collection, Canberra (ANIC). Further abbreviations of collections are: CMC, Collection B.P. Moore, Canberra, in ANIC; DPI, Department of Primary Industries, Mareeba.

Specimens for male genitalia dissection were soaked in a moist jar overnight, then the genitalia were cleaned briefly in hot 4% KOH. The photographs were made using SPOT Advanced for Windows 3.5 and subsequently were worked with Corel Photo Paint 10.

Holotype label data are given in full but for other specimens collectors' names and other terms are abbreviated as follows: DC, D.J. Cook; DY, D.K. Yeates; GM, G.B. Monteith; GT, G.I. Thompson; HJ, H.A. Janetzki; LR, L. Roberts; PB, P. Bouchard; RS, R. Sheridan; SM, S.R. Monteith; Pyr., pyrethrum knockdown; QM Berl., Queensland Museum Berlesate No.; Rf, rainforest; Tbld, Tableland.

Descriptions. Because of similarity in external and genitalic characters within most taxa of *Mecyclothorax*, *Sitaphe*, and *Raphetis*, generally one species of each genus is fully described, then for the other taxa only characters that differ are noted. This is done so as to reduce repetition, but was not applied to species that differ more substantially.

Measurements. Measurements were taken using a stereo microscope with an ocular micrometer. Length has been measured from apex of labrum to apex of elytra. Lengths, therefore, may slightly differ from those of other authors, especially Moore (1963, 1984). Length of pronotum was measured along midline, width of pronotum at widest part, width of base of pronotum at the extreme tips of the basal angles, though in those species of *Sitaphe* that have the lateral margin incurved to the basal angle, width of base was measured immediately in front of the basal angle. In the measurements of *Raphetis* species length of eye includes a small dark coloured ring of ocellae behind the light area. Ratios are somewhat variable in most species, but generally offer good indication of relative shape.

Taxonomic Principles. Interpretation of the taxonomic status of the many highly similar populations is difficult in all genera that occur in the Wet Tropics. For the time being, at least until additional distribution information is available, I have decided to treat those populations that show slight though apparently constant differences as subspecies, when they are allopatric, and as species, when they are obviously sympatric (e.g. in *Sitaphe*). In a couple of taxa the morphological

differences, in either the male genitalia or external structure, are very weak and do not justify description as species. Because several other carabid genera (and also some non-carabid groups) on mountain tops in the Wet Tropics of northeastern Queensland are likewise segregated into many closely related but apparently well distinguished units (be they species or subspecies!) on adjacent mountain ranges (e.g., Darlington, 1961a, 1961b; Baehr, 1995b; Monteith, 1997; Bouchard, 2002), this treatment seems to accommodate the complex situation best. Other non-morphological methods may be useful to interpret the taxonomic status of the different populations. For further comments see 'Discussion'.

Although ranges are included in the keys, range should not be used as a distinguishing character *per se*, even when the ranges of most taxa are apparently restricted and well separated.

Laccocenus Sloane, 1890

Laccocenus Sloane, 1890: 644; Csiki 1929: 484; Moore 1963: 286, Moore et al. 1987: 153.

TYPE SPECIES. *Laccocenus ambiguus* Sloane, 1890.

REMARKS. This is the sole Australian genus of the tribe Nomiini s.str. Until recently monotypic, an additional species has been found in a cave in southeastern New South Wales and is being described at present (Moore, in press).

Laccocenus ambiguus Sloane, 1890

Laccocenus ambiguus Sloane, 1890: 646; Csiki 1929: 484; Moore 1963: 286; Moore et al. 1987: 153

REMARKS. A rather common species living in and under rotten wood or under bark of fallen logs in subtropical to temperate rain forest.

DISTRIBUTION. Northeastern New South Wales (type locality: Dunoon, near Lismore) and at the following high elevation localities (QM specimens) along the Macpherson Range, Queensland: (east to west) Tomewin Range; Repeater Station, Springbrook; Mt Bithongabel and Westcliff Track, Lamington Plateau; Mt Chinghee; Mt Superbus; Bald Mountain, via Emu Vale.

Mecyclothorax Sharp, 1903

Mecyclothorax Sharp, 1903: 243; Csiki 1929: 487; Moore 1963: 286; Moore 1984: 161; Moore et al. 1987: 147.

TYPE SPECIES. *Cyclothorax montivagus* Blackburn, 1878.

REMARKS. A genus of the tribe Mecyclothoracini that also includes *Neonomius* Moore in Australia. *Mecyclothorax* is widely distributed throughout eastern, southern and southwestern Australia, and altogether 16 species were described from Australia. Moore (1984), who published a partial revision of the genus (the *ambiguus*-group) and described two new species from North Queensland, stated that the genus urgently needs revision.

Outside Australia, *Mecyclothorax* is widely distributed in New Guinea, New Caledonia, Borneo, Java, Hawaii, Tahiti, New Zealand, Norfolk Island, Lord Howe Island and several subantarctic islands, e.g. Amsterdam and St. Paul (Baehr 1992, 1995a, 1998, 1999, 2000, in press b, Baehr & Lorenz 1999, Britton 1948, Darlington 1962, 1971, Deuve 1987, Jeannel 1944, Louwerens 1949, Mandl 1969, Moore 1984, 1985, 1992, Moore et al. 1987, Perrault 1978, 1992). In Australia a distinct, probably apotypic, group of tropical species is well separated from the range of the main body of the genus in Australia which is essentially southern.

KEY TO THE QUEENSLAND TAXA OF *MECYCLOTHORAX* SHARP

1. Pronotum almost orbicular, lateral margin shortly excised in front of basal angles, elytra longer, striae deeply punctate. Size >5mm. Central and southeastern Queensland . . . . . *punctipennis* (Macleay)

   Pronotum more or less cordate, lateral margin not excised in front of basal angles, elytra shorter and wider, striae mostly barely punctate. Size <3.5mm 2

2. Clypeus bisetose; base of pronotum coarsely punctate, basal angles without seta, anterior transverse impression deep; aedeagus abnormal, side-inverted and turned to the right side. 3

   Clypeus quadrisetose; base of pronotum not or barely punctate, basal angles usually with setae, anterior transverse impression barely indicated; aedeagus normal, turned to the left side. 4

3. Pronotum not sinuate in front of base; aedeagus larger, apex shorter and wider, internal sac with two small spinose areas in front (Fig. 1A). Bellenden Ker Range, Massey Range . . . . . *storeyi storeyi* Moore

   Pronotum slightly sinuate in front of base; aedeagus smaller, apex longer and narrower, internal sac without spinose areas in front (Fig. 1B). Bartle Frere Range . . . . . *storeyi frerei* subsp. nov.

4. Lateral margins of pronotum not perceptibly sinuate posteriorly; genital ring with very elongate apex (Fig. 1E). 5

   Lateral margins of pronotum perceptibly sinuate posteriorly; genital ring, when known, with shorter apex (Figs 1C-D). 6

5. Spinose fields within apex of orificium of aedeagus smaller, situated at left and right sides (Fig. 1E). Southwestern Part of Atherton Tbld: Mt Fisher, Mt Hugh Nelson, Mt Father Clancy, Malaan Rd nr Palmerston Hwy.. . . . . *inflatus inflatus* sp. nov.

   Spinose fields within apex of orificium of aedeagus very large, situated only at the right side (Fig. 1F). Upper

Boulder Creek at Walter Hill Range . . . . . *inflatus spinifer* subsp. nov.

6. Four inner striae of elytra impressed and coarsely punctate. Isley Hills, ne. Atherton Tbld . . . . . *impressipennis* sp. nov.

Inner striae of elytra at most lightly impressed and finely punctate. 7

7. Apex of aedeagus rounded off, genital ring with longer apex (Fig. 1C); pronotum with comparatively wider base, ratio base/apex >1.20. Carbine Tbld, Thornton Peak, Mt Pieter Botte, north of Thornton Peak . . . . . *lewisensis lewisensis* Moore

Apex of aedeagus sharply spined, genital ring with considerably shorter apex (Fig. 1D); pronotum with comparatively narrower base, ratio base/apex <1.17. Mt Hemmant, Mt Halcyon, Roaring Meg Ck, mountain tops near Cape Tribulation, all north of Thornton Peak . . . . . *lewisensis uncinatus* subsp. nov.

Mecyclothorax punctipennis (Macleay, 1871)

Cyclothorax punctipennis Macleay, 1871: 105.
Mecyclothorax punctipennis, Csiki, 1929: 487; Moore, 1984: 162; Moore et al., 1987: 149.
Cyclothorax obsoletus Blackburn, 1889: 1389.

REMARKS. A common species in southeastern Queensland, where it is found in subtropical rain forest on Lamington Plateau, Main Range, Bunya Mountains, and further north to about Gayndah (the type locality) where it has been recollected recently (QM). One rather recent record is available from Blackdown Tableland further north (QM). There, and at scattered localities in low country, the species also occurs in more open habitats. It lives on the ground, but also on and sometimes even under bark of logs and standing trees. Moore (1984) demonstrated the differences between *M. punctipennis* and the rather similar *M. ambiguus* Erichson, under which name *M. punctipennis* was still noted by Csiki (1929).

DISTRIBUTION. Whole southern Australia from southern half of Western Australia to southern Queensland as far north as Tropic of Capricorn (Moore et al., 1987). Recently recorded also from Tasmania (Baehr, 2000).

Mecyclothorax storeyi Moore, 1984

Mecyclothorax storeyi Moore, 1984: 164; Moore et al., 1987: 149.

Small, conspicuously coloured species living at high altitude in rain forest litter. So far known from Bellenden Ker, Bartle Frere, and Massey Ranges at the eastern margin of Atherton Tableland. As the population living on Mt Bartle Frere shows significant differences in shape and structure of the male aedeagus, it is described as a distinct subspecies.

M. storeyi is peculiar in possessing strikingly abnormal male genitalia, because aedeagus and parameres are side-inverted and moreover, are turned to the right side of the beetle, which is opposite to all other species of *Mecyclothorax* and to Psydrinae in general. During ample dissections of almost 100 species and several hundred specimens of the amblytelines *Amblytelus*, *Dystrichothorax*, and *Epelyx*, I found a similar inversion only twice in single specimens of two species that normally possess normal shaped aedeagi turned to the left side of the body. Moore (1984, fig. 15) recognised this inversion, but confused the parameres, describing the left one as 'small, styloid, setose laterally' and the right one as 'larger, conchoid, setose apically'. Nevertheless the parameres are normal, but the whole male genitalia are inverted which means that the left paramere in situ is the right one morphologically, and *vice versa*.

To clarify the situation, and because the species includes two subspecies that differ in certain characters of the aedeagus, and finally, because the setosity of the parameres is incorrectly figured in the description, the genitalia of both subspecies are (re)described and figured herein.

DIAGNOSIS. Small species, distinguished by the side-inverted aedeagus with straight instead of downcurved apex, bisetose clypeus (as usual for the genus), absence of the posterior pronotal seta, deeply impressed anterior transverse sulcus of pronotum, and rather narrow base of the basally coarsely punctate pronotum.

REMARKS. With respect to several differences between this and the following small, flightless species from North Queensland, *M. storeyi* is a rather isolated species within this group, whereas all following species form a distinct group of very closely related taxa.

Mecyclothorax storeyi storeyi Moore, 1984 (Figs 1A, 2A, 5)

Mecyclothorax storeyi Moore, 1984: 164; Moore et al., 1987: 149.

MATERIAL. HOLOTYPE: ♂, N Qld, Mt Bellenden Ker (summit), from leaf litter, 19.i.1977, B.P. Moore (ANIC). PARATYPES: 35 ex. from same locality (in ANIC, CMC, DPI, and QM).

NEW RECORDS: 6 ♂, 24 ♀, Bellenden Ker, Centre Peak Summit, 10.iv.1979, GM, QM Berl. No. 9 17.16S 145.51E Rf, 1500m Sieved litter (CBM, QM); 1 ♀, same loc., 10.iv.1979 GM, QM Berl. 12 Rf, Stick brushings (QM); 9 ♂, 7 ♀, same loc., 11.iv.1979 GM, QM Berl. Rf, Sieved litter (QM); 15 ♂, 5 ♀, same loc., 11.iv.1979 GM /QM Berl. 14 ,Rf, Sieved litter (QM); 1 ♂, same loc., 11.iv.1979 GM, QM Berl. 15, Rf, Stick brushings (QM); 2 ♀, same

loc., 11.iv.1979 GM, QM Berl. 16, Rf, Stick brushings (QM); 4 ♂, 1 ♀, same loc., 11.iv.1979 GM, QM Berl. 17, Rf, Sieved litter (QM); 1 ♂, 4 ♀, same loc., 28.viii.1991 GM & HJ, QM Berl. No. 852, Rf, 1560m , Sieved litter (QM); 1 ♀, Bellenden Ker, Cable Tower No. 3, 12.iv.1979 GM, QM Berl. 21 17.16S 145.52E Rf, 1000m Sieved litter (QM); 4 ♂, 5 ♀, Bellenden Ker Summit 10.vi.1980 GM, QM Berl. No. 220 17°16'S 145°52'E Rf, 1561m Sieved Litter (QM); 8 ♂#, 4 ♀ , Bellenden Ker Range. NQ Summit TV Stn., 1560m, 17.16S 145.51E, Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 334, Rf Sieved litter (QM); 5 ♂#, 2 ♀ , same loc., Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 335, Rf Sieved litter (QM); 8 ♂#, 5 ♀, same loc., Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 336, Rf Sieved litter (CBM, QM); 8 ♂#, 6 ♀ ,same loc., Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 337 Rf Sieved litter (QM); 7 ♂#, 2 ♀ , same loc., Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 338, Rf Sieved litter (QM); 1 ♀ , same loc. Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 343, Rf Stick & Moss brushings (QM); 11 ♂, 8 ♀ , same loc. Oct 25-31, 1981 Earthwatch/QM, QM Berl. 371, Rf Sieved litter (CBM, QM); 5 ♂m, 3 ♀ , same loc. Oct 25-31, 1981 Earthwatch/QM, QM Berl. 372, Rf Sieved litter (QM); 5 ♂, 3 ♀ , same loc. Oct 25-31, 1981 Earthwatch/QM, QM Berl. 374, Rf *Dracophyllum* litter (QM); 9 ♂, 5 ♀ , same loc. Oct 25-31, 1981Earthwatch/QM, QM Berl. 375, Rf Sieved litter (QM); 2 ♂, 3 ♀ , same loc.Oct 20-23, 1981 Earthwatch/QM, QM Berl. 376, Rf Sieved litter (QM); 8 ♂, 6 ♀, same loc. 28.x.1983 GM, DY & GT, QM Berl. No. 601, Rf, Sieved litter (QM); 11 ♂, 9 ♀, same loc. 28.x.1983 GM, DY & GT, QM Berl. No. 602, Rf, Sieved litter (CBM, QM); 2 ♂, same loc.,16 April 1999 GM & SM, QM Berl. 993, Rf, Moss ex trees & logs (QM); 1 ♂, same loc., 17 April 1997 GM & Russell, QM Berlesate 930 17°16'S 145°52'E Rf, Sieved leaf litter (QM); 6 ♂, 3 ♀, same loc. 1.xii.1998 GM, QM Berl. 977, Sieved litter (QM); 5 ♂, 1 ♀, AUST: Qld: NE: Bellenden Ker, 1994 Crash. 1.xii.1998 GM, QM Berl. 978 17°16'S 145°51'E Rf, 1325m Sieved litter (QM);2 ♀, Mt Bellenden Ker Qld rain forest 12.xii.1976 Walford-Huggins / *Mecyclothorax storeyi* Moore (CBM); 1 ♂, Massey Range, NQ 12km S Gordonvale 2.v.1983 GM, DC, QM Berl. No. 573 17.16S 145.59E Rf, 1300m sieved litter (QM);6 ♂, 3 ♀, NE Qld. Thornton Peak, via Daintree, 20-22.ix.1981 GM & DC, QM Berl. 301 Rf, 1000-1300m Sieved litter & moss (QM) (probably wrong label! See further diseussion under *M. lewisensis).*

DIAGNOSIS. As the species was described from individuals from Bellenden Ker Range, this population is the nominate subspecies. It is distinguished from the southern population living on Mt Bartle Frere, *M. s. frerei* subsp. nov., by considerably larger aedeagus bearing a shorter and wider apex and two small spinose fields at the opening of the internal sac, and by wider base of pronotum the lateral margins of which, on average, are less sinuate near base.

DESCRIPTION. *Measurements.* Length: 2.8-3.25mm; width: 1.35-1.5mm; Ratios. Length/width of 9th antennomere: 1.8-2.0; width/length of pronotum: 1.24-1.30; width base/apex of pronotum: 1.10-1.15; width pronotum/head: 1.51-1.60; length/width of elytra: 1.24-1.27; width elytra/pronotum: 1.36-1.38.

Colour. As in the southern subspecies, colouration of the nominate subspecies is very diverse. Although head and pronotum are always black, colour of the elytra can vary from almost completely black, to completely reddish, to blackish or dark reddish with light margin, or with light humeral area only, or quadrimaculate with light humerus and light apex.

Male genitalia (Fig. 1A). Genital ring short and wide, highly asymmetrically triangular, with characteristic angle laterally, apex narrow and rather elongate. Aedeagus side-inverted, turned to the right side (in beetle), narrow and elongate (in genus), lower surface evenly concave. Apex fairly elongate, wide, straight, evenly rounded off. Internal sac rather complexly folded, with several narrow, sclerotized plates within. On left side of apical end of (inverted) internal sac with two strongly spinose fields. Both parameres comparatively elongate, triangularly convex, with narrow, elongate apex. Left (in situ right!) paramere larger than right (in situ left!), with 1-2 short apical setae. Right (in situ left!) paramere with 2 apical and 5-8 moderately elongate setae along the apical half of lower margin.

Female genitalia (Fig. 2A). Stylomere 1 with one, rarely two elongate ensiform seta(e) at lateral part of ventro-apical margin. Stylomere 2 rather short, with short apex and two large dentiform ventro-lateral ensiform setae of about similar size below middle of lateral margin. Near apex with a large, oblong pit and a short nematiform seta originating from that pit. In middle of dorso-median surface with a large, dentiform, dorso-median ensiform seta. Lateral plate with a densely setose area at median apical margin.

Variation. A rather variable subspecies with respect to relative shape and, in particular, to colour and distinctness of pattern of elytra. Also puncturation of base of pronotum, and degree of puncturation and depth of elytral striae vary to some extent.

DISTRIBUTION (Fig. 5). Bellenden Ker and Massey Ranges at the eastern margin of Atherton Tableland.

COLLECTING CIRCUMSTANCES. Generally collected by Berlese extraction or by sieving of

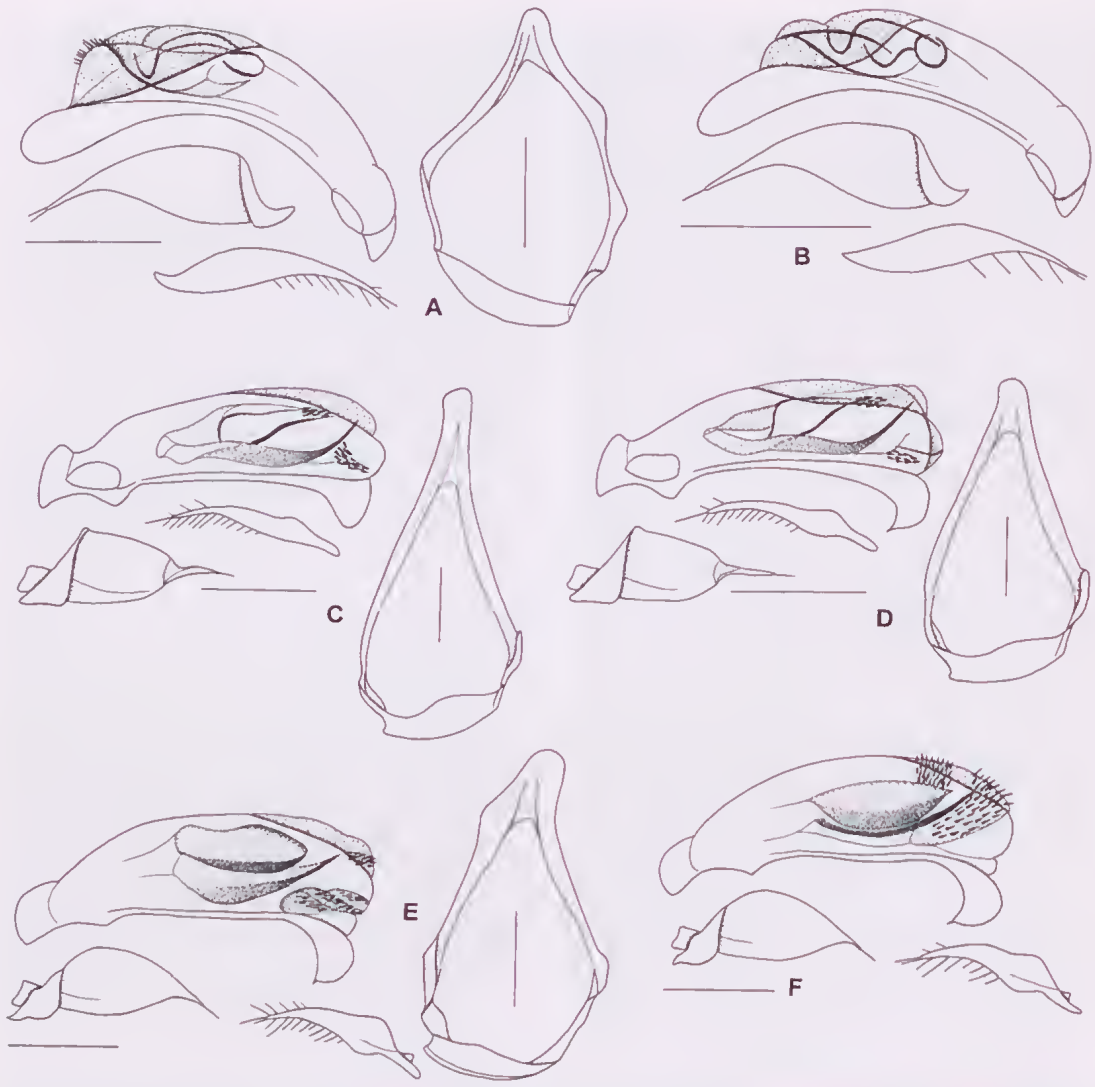

FIG. 1. Male genitalia of *Mecyclothorax* spp. A, *M. storeyi storeyi* Moore, aedeagus, parameres, and genital ring; B, *M. storeyi frerei* subsp. nov., aedeagus and parameres; C, *M. lewisensis lewisensis* Moore, aedeagus, parameres, and genital ring; D, *M. lewisensis uncinatus* subsp. nov., aedeagus, parameres, and genital ring; E, *M. inflatus inflatus* sp. nov., aedeagus, parameres and genital ring; F, *M. inflatus spinifer* subsp. nov., aedeagus and parameres. Scales: 0.25mm.

ground litter from upland rain forest. A few were collected by 'stick brushings' and in pitfall traps. Most specimens are from the absolute summits of the respective ranges.

Mecyclothorax storeyi frerei subsp. nov.
(Figs 1B, 3A-B, 4A, 5)

ETYMOLOGY. The name refers to the type locality, Mt Bartle Frere, Queensland's highest peak.

MATERIAL. HOLOTYPE: ♂, QMT21216, NE Qld, Mt Bartle-Frere, summit creek, 24.ix.1981 G. Monteith & D. Cook, QM Berl. 304 Rf, 1500m Sieved litter (QM). PARATYPES: 2 ♂, 3 ♀, same data (CBM, QM); 9 ♂, 14 ♀, Mt Bartle Frere, N Qld. 0.5km N of Sth Peak 6-8 Nov. 1981 Earthwatch/QM, QM Berl. 357 17.24S 145.49E Rf Sieved litter (CBM, QM); 10 ♂, 6 ♀, Mt Bartle Frere, N Qld. NW/Centre Peak ridge 7-8.x.1981, 1400-1500m Earthwatch/QM, QM Berl. 358 17.23S 145.48E Rf Sieved litter (CBM, QM); 6 ♂, 10 ♀, Mt Bartle Frere, N Qld. Sth Peak Summit, 1620m 6-8 Nov. 1981 Earthwatch/QM, QM

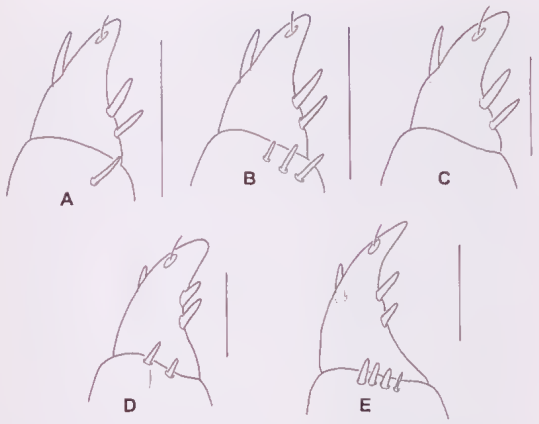

FIG. 2. Stylomere 2 and apex of stylomere 1. A, *Mecyclothorax storeyi storeyi*; B, *M. lewisensis lewisensis*; C, *Sitaphe rotundata* Moore; D, *Raphetis curta* sp. nov.; E, *R. gracilis gracilis* Moore. Scales: 0.1mm.

Berl. 354 17.24S 145.49E Sieved litter (CBM, QM); 3 ♂, same loc. 6-8 Nov. 1981 Earthwatch/QM, QM Berl. 359, Sieved litter (QM).

DIAGNOSIS. This subspecies is distinguished from the nominate subspecies by considerably smaller aedeagus bearing a longer and narrower apex and lacking the spinose fields at the opening of the internal sac, and by narrower base of pronotum, the lateral margins of which are more distinctly sinuate towards base.

DESCRIPTION. *Measurements.* Length: 2.65-3.15mm; width: 1.2-1.45mm; Ratios. Length/width of 9th antennomere: 1.9-2.1; width/length of pronotum: 1.29-1.32; width base/apex of pronotum: 1.07-1.10; width pronotum/head: 1.43-1.50; length/width of elytra: 1.25-1.29; width elytra/pronotum: 1.33-1.34.

Colour (Fig. 4A). Black, though colouration of elytra as variable as in nominate subspecies: uniformly black, or reddish, of with light lateral margin, or more or less conspicuously quadrimaculate.

Head. As in nominate subspecies with clypeus in middle remarkably convex, frontal furrows deep, curved, prolonged onto clypeus, eyes convex, laterally produced, with large orbits of c. 1/3 of length of eye, with eyes separated from frons and vertex by very deep sulcus. Surface absolutely smooth.

Pronotum (Fig. 3A). As in nominate subspecies, though anteriorly even wider and remarkably convex, base relatively narrower and perceptibly sinuate in front of the obtuse basal angles. Base coarsely punctate and basal angle without basal lateral seta, as in nominate subspecies.

Elytra (Fig. 3B). As in nominate subspecies. Scutellar stria always lacking, sutural stria deeply impressed and distinctly punctate, outer striae far less impressed, commonly only punctate.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 1B). As in nominate subspecies, though aedeagus smaller, with longer apex, on lower surface slightly less curved, and without the spinose fields at apex of the (inverted) internal sac. Right (in situ left!) paramere with only 4-5 setae on lower margin.

Female genitalia. As in nominate subspecies.

Variation. Little variation noted, except for colouration of elytra, and depth of outer elytral striae.

DISTRIBUTION (Fig. 5). Mt Bartle Frere, on the eastern fringe of Atherton Tableland.

COLLECTING CIRCUMSTANCES. Most specimens sampled by 'sieving litter' in montane rainforest. This subspecies was collected only on the summit plateau, above 1500m.

Mecyclothorax lewisensis Moore, 1984

Mecyclothorax lewisensis Moore, 1984: 165; Moore et al. 1987: 148.

REMARKS. Small, conspicuously coloured species living at high altitude in rain forest litter. So far known from Mt Lewis and certain localities at the southern fringe of Carbine Tableland, also from Thornton Peak and Mt Pieter Botte north of Daintree River. As the northernmost population living on Mt Hemmant, Mt Halcyon, and Mt Sorrow near Cape Tribulation shows significant differences in shape of the male aedeagus, this population is described as a distinct subspecies.

In contrast to *M.* storeyi, *M. lewisensis* has normally shaped and directed male genitalia, that, however, show rather apomorphic features in the apex of the aedeagus and the left paramere.

There is some confusion as to presence or absence of the basal prothoracic seta. Moore (1984: 165-166) stated that 10 specimens he examined from Thornton Peak lack this seta, which is unusual and opposite to all other specimens that I have examined. Through courtesy of G. Monteith I had the opportunity to see all QM material including the 10 mentioned

specimens from Thornton Peak. Thereby it appeared that only one specimen belongs to *M. lewisensis* which lacks the basal prothoracic seta though not the puncture, whereas the nine other specimens belong to *M. storeyi*. Apparently, some confusion of labelling has occurred, because it is extremely improbable that *M. storeyi* should occur on Thornton Peak. As a conclusion, Moore's (1984) statement that *M. lewisensis* is highly variable in this character does not apply.

Because *M. lewisensis* includes two subspecies that differ in certain characters of the aedeagus, and moreover, because structures of the internal sac are omitted and the setosity of the parameres is incorrectly figured in the description (Moore, 1984, fig. 16), the genitalia of both subspecies are (re)described and figured herein.

DIAGNOSIS. Small, with cordate prothorax that bears sharply angulate basal angles; clypeus quadrisetose (as in all following species): distinguished by the apically very elongate male genital ring. Further distinguished from *M. storeyi* Moore by not side-inverted aedeagus and the basal pronotal seta; from *M. impressipennis* sp. nov. by narrower, less quadrate elytra with far less deeply punctate inner striae and by narrower base of pronotum; and from *M. inflatus* sp. nov. by narrower base of pronotum bearing angulate basal angles, and by less spinose apex of internal sac of aedeagus, longer right paramere, and presence of a membranous area near apex of left paramere.

Mecyclothorax lewisensis lewisensis Moore
(Figs 1C, 2B, 6)

Mecyclothorax lewisensis Moore, 1984: 165; Moore et al., 1987: 148.

MATERIAL. HOLOTYPE: ♂, N Qld, Mt Lewis, 16.i.1975, B.P. Moore (ANIC). PARATYPES: 23 ex. from same locality (in ANIC, CMC, and QM).

NEW RECORDS. 1 ♂, 2 ♀, Australien, Qld. Mt Lewis, 1000m 6.1.1982 M. Baehr/*Mecyclothorax lewisensis* Moore (CBM); 7 ♂, 4 ♀, Mt Lewis, road end 18.xi.1997 GM, QM Berl. 950, 16°30'S 145°15'E, Rf, 1120m Sieved litter (CBM, QM); 1 ♂, 2 ♀, Mt Lewis Rd 29km from Hwy 29.xi.1997 DC, QM Berl. 964 16°31'S 145°16'E, Rf, 1210m Leaf litter (QM); 3 ♀, 2.5km N Mt Lewis via Julatten 3.xi.1983 DY & GT, QM Berl. No. 610 16.34S 145.16E Rf, 1040m Sieved litter (QM); 2 ♂, 1 ♀, same loc., 3.xi.1983 DY & GT, QM Berl. No. 611, Rf, 1040m Sieved litter (QM); 2 ♂, same loc., 3.xi.1983 DY GT, QM Berl. No. 612, Rf, 1040m Sieved litter (QM); 2 ♂, 7.5km N Mt Lewis, via Julatten, 8.ix.1981 GM & DC, QM Berl. 279 Rf, 1200m Sieved litter (QM); 1 ♂, 2 ♀ 5.5km N Mt Lewis, via Julatten, 8.ix.1981 GM & DC, QM Berl. 276 Rf, 1100m Sieved litter (QM); 1 ♂, same loc., 8.ix.1981 GM & DC, QM Berl. 275 Rf, Sieved litter (QM); 3 ♂, 1 ♀, Mt Lewis, 18km N 23.xi.1998 GM, QM Berl. 975 16°30'S 145°16'E, Rf, 1300m Moss and litter (QM); 5 ♂, 5 ♀, Mt Demi, 7km SW Mossman 29.x.1983 DY GT, QM Berl. No. 604 16.30S 145.19E Rf 1100m Sieved litter (CBM, QM); 1 ♀, same loc., 29.x.1983 DY GT, QM Berl. No. 603, Rf, Sieved litter (QM); 9 ♂, 3 ♀, Hilltop, 5.5.km N Mt Lewis, 13.ix.1981 GM & DC, QM Berl. 297 Rf, 1200m Sieved litter (CBM, QM); 13 ♂, 5 ♀, same loc.,13.ix.1981 GM & DC, QM Berl. 297 Rf, 1200m Sieved litter (CBM, QM); 2 ♀, The Bluff, 11km W of Mossman 29 April 1983 GM, DY, QM Berl. No. 551 16.27S 145.16E Rf, 1050m litter (QM); 1 ♂, 2 ♀, same loc., 29 April 1983 GM, DY, QM Berl. No. 554, Rf, 900-1000m litter (QM); 1 ♀, same loc.29 April 1983 GM, DY, QM Berl. No. 555, Rf, 900-1000m litter (QM); 1 ♀, same loc., 29 April 1983

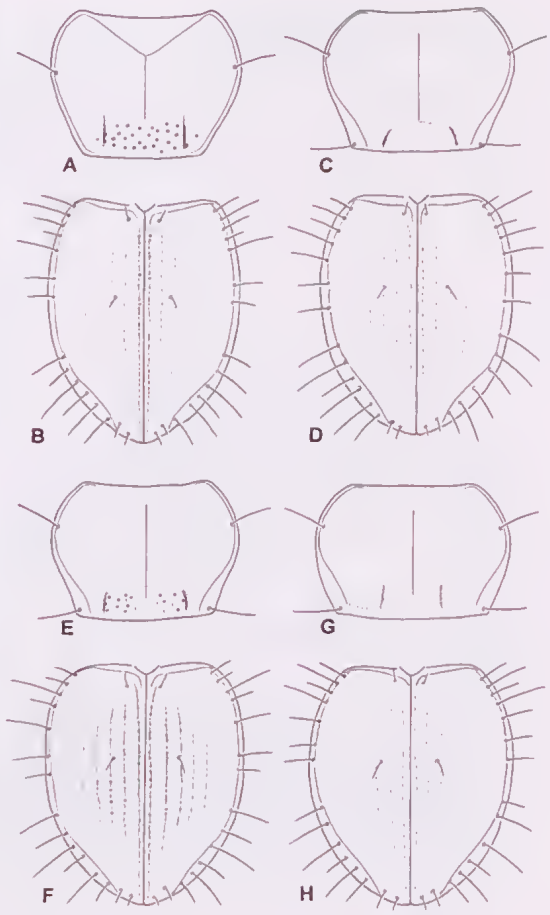

FIG. 3. Pronota and elytra of *Mecyclothorax* spp. A, B, *M. storeyi frerei* subsp. nov.; C, D, *M. lewisensis uncinatus* subsp. nov.; E, F, *M. impressipennis* sp. nov.; G, *M. inflatus spinifer* subsp. nov.; H, *M. inflatus inflatus* sp. nov.

GM, DY, QM Berl. No. 556, Rf, 900-1000m litter (QM); 2 ♂, 1 ♀, same loc., 2.xi.1983 GM, DY & GT, QM Berl. No. 609, Rf, 1000m litter (QM); 1 ♀, Carbine Tbld, N Qld Mossman Bluff Camp, 30.xi.1990, 1000m GM & HJ Pitfall Traps (QM); 6 ♂, 3 ♀, Devils Thumb area 10km NW Mossman 9.x.1982 GM, DY & GT, QM Berl. No. 456 16.34S 145.17E Rf 1000-1180m Sieved litter (QM); 2 ♂, 6 ♀, same loc. 9.x.1982 GM, DY & GT, QM Berl. No. 457, Rf 1150m Sieved litter (QM); 2 ♂, 5 ♀, same loc., 9.x.1982 GM, DY & GT, QM Berl. No. 461, Rf, Sieved litter (QM); 1 ♂, 1 ♀, same loc., 10.x.1982 GM, DY & GT, QM Berl. No. 459, Rf 1180m Sieved litter (QM); 7 ♂, 7 ♀, same loc., 9-10.x.1982 GM, DY & GT, QM Berl. No. 455, Rf 1000-1180m Sieved litter (CBM, QM); 2 ♂, same loc., 9.x.1982 GM, DY & GT, QM Berl. No. 455, Rf, 1000-1180m Sieved litter/ *Mecyclothorax lewisensis* Moore Det. GM 1989 (CBM); 1 ♀, Devil's Thumb - Pauls Luck, 12km WNW Mossman, NQ 27.xii.1989 - 15.i.1990 ANZSES Expedition Site 12, 1300m, pitfall (QM); 9 ♂, 9 ♀, Upper Whyanbeel Creek 5.ix.1992 GM, QM Berl. No. 859 16°23' 145°17', 1150m Rf, litter (QM); 1 ♂, 7km N Mt Spurgeon (Camp 2) 17-19.x.1991. 1200-1250m 16°22'S 145°13'E GM, DC & LR Pitfall Traps (QM); 6 ♂, 2 ♀, same loc., GM & HJ, QM Berl. No. 857 Rf. 1250m Sieved litter (CBM, QM); 4 ♂, 1 ♀ , 4km NNE Mt Spurgeon 15.x.1991 GM & HJ, QM Berl. No. 854 16°24'S 145°13'E Rf. 1250m Sieved litter (QM); 1 ♀, 3.5km NNE Mt Spurgeon 15-20.x.1991, 1350m 16°24'S 145°13'E GM, HJ, DC & LR. PITFALLS (QM); 1 ♂, Stewart Ck, 4km NNE Mt Spurgeon (Camp 1), 1250-1300m 16°24'S 145°13'E 15-20.x.1991. PITFALLS GM, DC & LR (QM); 1 ♂, 2km SE Mt Spurgeon via Mt Carbine, N Qld. 20.xii.88-4.i.1989 GM, GT & ANZSES 1100m, RF, pitfall (QM); 1 ♂, Thornton Peak, via Daintree, 20-22.ix.1981 GM & DC, QM Berl. 301 Rf, 1000-1300m Sieved litter & moss (QM); 3 ♂, 5 ♀ , Thornton Peak summit, via Daintree 24-27.ix.1984 GM & SM, QM Berl. 662 Rf, 1100-1300m Sieved litter & moss (CBM, QM); 3 ♂, Granite Outcrops 0.5km E. Mt Pieter Botte 5.x.1982 GM, DY & GT, QM Berlesate No. 450 16.05S 145.23E Rf, 780m Sieved litter (CBM, QM).

DIAGNOSIS. As the species was described from individuals from Mt Lewis, the population showing similar genitalic morphology is the nominate subspecies. It is distinguished from the northern subspecies *M. l. uncinatus* subsp. nov. by evenly rounded apex of aedeagus, generally narrower pronotum with wider base, and, on average, longer elytra.

DESCRIPTION. *Measurements*. Length: 2.8-3.25mm; width: 1.35-1.5mm; Ratios. Length/width of 9th antennomere: 1.65-1.8; width/length of pronotum: 1.32-1.36; width base/apex of pronotum: 1.21-1.25; width pronotum/head: 1.48-1.54; length/width of elytra: 1.22-1.27; width elytra/pronotum: 1.37-1.42.

Colour. Rather variable, blackish to more or less dark piceous, elytra commonly lighter, reddish-piceous to reddish, more or less inconspicuously quadrimaculate, though apical spots always present and rather distinct, invariably somewhat oblique.

Pronotum. Contrary to the description (Moore 1984, p. 165) all examined specimens bear the posterior lateral seta, including all specimens from Thornton Peak. Most probably Moore included in this species by error a wrongly labelled sample of *M. storeyi* that, unfortunately, also included a single specimen of *M. lewisensis* with setae broken on both sides (series examined by me).

Male genitalia (Fig. 1C). Genital ring elongate, triangular, slightly asymmetric, apex narrow and very elongate. Aedeagus normal, turned to the left side (in beetle), rather short and compact (in genus), lower surface almost straight, but suddenly curved down in front of apex. Apex short and wide, obtusely triangular, suddenly turned down. Internal sac rather complexly folded, with two narrow elongate spine-shaped sclerotized plates within. On left side and at roof of (inverted) internal sac with a strongly spinose field each. Parameres very dissimilar, left comparatively stout, with spine-like, thin apex and small membranous area between basal part and apex, with a single short apical seta. Right paramere narrow and elongate, with tapering apex, with 1 apical seta, c. 10 rather elongate setae on lower margin, and 2-3 shorter setae on apical third of upper margin.

Female genitalia (Fig. 2B). Stylomere 1 with 2-3 elongate ensiform setae at lateral part of ventro-apical margin. Stylomere 2 rather short, with short apex and 2 large dentiform ventro-lateral ensiform setae of about similar size below middle of lateral margin. Near apex with a large, oblong pit and a short nematiform seta originating from that pit. In middle of dorso-median surface with a large, dentiform, dorso-median ensiform seta. Lateral plate with a densely setose area at median apical margin.

Variation. A rather variable subspecies with respect to relative shape of pronotum and elytra, colour and distinctness of colour pattern, and depth and degree of puncturation of elytra. Especially the specimens from Mt Spurgeon in western part of Carbine Tableland tend to have rather well impressed and coarsely punctate elytra, though this is not regarded as more than a local variation. All examined specimens from Mt Spurgeon and Thornton Peak possess the

FIG. 4. Habitus of *Mecyclothorax*. A, *M. storeyi frerei* subsp. nov.; B, *M. lewisensis uncinatus* subsp. nov.; C, *M. impressipennis* sp. nov.; D, *M. inflatus inflatus* sp. nov. Lengths: 3.0mm; 2.95mm; 3.2mm; 3.05mm.

scutellar pore and seta, whereas these are apparently absent in all other populations.

DISTRIBUTION (Fig. 6). Carbine Tableland north of Mossman (Mt Lewis, Mt Demi, Mossman Bluff, Devils Thumb, Mt Spurgeon), and Thornton Peak and Mt Pieter Botte, both north of Daintree River, North Queensland.

COLLECTING CIRCUMSTANCES. Most were collected from rain forest leaf litter by Berlese extraction, with a few from ground pitfall traps. These are clearly ground dwellers invariably occurring on the highest peaks of mountains and tablelands and not descending below about 750m.

Mecyclothorax lewisensis uncinatus subsp. nov.
(Figs 1D, 3C-D, 4B, 6)

ETYMOLOGY. The name refers to the sharply hooked apex of aedeagus.

MATERIAL. HOLOTYPE: ♂, QMT21587, AUST: NE Qld, Mt Haleyon 24 Nov 1993 G Monteith & H. Janetzki, QM BERLESATE No. 864 16°03'S 145°25'E Rf, 870m Leaf litter (QM). PARATYPES: 2 ♂, 2 ♀, same data (CBM, QM); 3 ♂, 4 ♀, Mt Hemmant 27.xi.1993 GM & HJ, QM Berl. No. 865 16°07'S 145°25'E Rf, 1050m Sieved leaf litter & moss (CBM, QM); 1 ♂, Roaring Meg Ck 6km W Cape Tribulation 5.x.1982 GM, DY & GT, QM Berl. No. 453 16.05S 145.24E Rf, 710m Sieved litter (QM); 1 ♂, 4.5-5km W of Cape Tribulation (Top Camp)

1.x.1982 GM, DY & GT, QM Berl. No. 442 16.05S 145.26E Rf, 760-780m Sieved litter (QM).

DIAGNOSIS. Distinguished from the nominate subspecies by the hook-shaped apical part of aedeagus bearing a sharply spined apex, considerably shorter apex of male genital ring, generally wider pronotum with narrower base, and, on average, shorter elytra.

DESCRIPTION. *Measurements.* Length: 2.9-3.1mm; width: 1.35-1.45mm; Ratios. Length/width of 9th antennomere: 1.6-1.8; width/length of pronotum: 1.34-1.41; width base/apex of pronotum: 1.14-1.17; width pronotum/head: 1.45-1.54; length/width of elytra: 1.19-1.24; width elytra/pronotum: 1.33-1.37.

Colour (Fig. 4B). As in nominate subspecies, maculate pattern in all examined specimens distinct.

Head. As in nominate subspecies with remarkably protruding eyes and small orbits.

Pronotum (Fig. 3C). As in nominate subspecies, though at the average slightly wider in anterior half and with relatively narrower base. Posterior lateral setae always present.

Elytra (Fig. 3D). As in nominate subspecies, though at the average slightly shorter. In all examined specimens all striae, including sutural stria, barely impressed and rather finely punctate. Contrary to most populations of the nominate subspecies, except for those occurring on Mt Spurgeon and Thornton Peak, sutural pore and seta always present.

Lower surface and legs. As in nominate subspecies.

Male genitalia (Fig. 1D). Generally similar to those of nominate subspecies, though apical part of genital ring considerably shorter and apex of aedeagus more curved downwards and with acute spine at end.

Female genitalia. As in nominate subspecies.

Variation. Little variation noted, except for slight differences in depth of puncturation of elytral striae.

DISTRIBUTION (Fig. 6). Mt Hemmant, Mt Halcyon and Roaring Meg Creek, north of Thornton Peak, North Queensland.

COLLECTING CIRCUMSTANCES. All specimens collected by sieving leaf litter and moss in montane rainforest. Therefore, this subspecies apparently lives in litter at the ground and in moss near the bases of trees. Collections were made between 710m and 1050m, mostly at the tops of the respective mountains.

Mecyclothorax impressipennis sp. nov.
(Figs 3E-F, 4C, 5)

ETYMOLOGY. The name refers to the deeply impressed four inner striae.

MATERIAL. HOLOTYPE: ♀, QMT21421, AUST: NE Qld, Isley Hills 1 Dec 1993 G. Monteith & H. Janetzki, QM Berlesate No 866 17°03'S 145°42'E Rainforest, 1050m Sieved litter & moss (QM). PARATYPE: 1 ♀, same data (CBM).

DIAGNOSIS. Small species with cordate prothorax that bears sharply angulate basal angles, clypeus quadrisetose; distinguished from all other species of this group by the very coarsely punctate, well impressed four to five inner elytral striae. Further distinguished from *M. storeyi* Moore by much wider pronotum with wider base that bears the posterior marginal setae; from *M. lewisensis* Moore by wider, more quadrate elytra with deeply punctate four inner striae and by wider base of pronotum; and from *M. inflatus* sp. nov. by narrower base of pronotum bearing angulate basal angles.

DESCRIPTION. *Measurements.* Length: 3.2mm; width: 1.52-1.55mm; Ratios. Length/width of 9th antennomere: 1.5; width/length of pronotum: 1.35-1.38; width base/apex of pronotum: 1.24-1.27; width pronotum/head: 1.49-1.56; length/width of elytra: 1.19-1.21; width elytra/pronotum: 1.40-1.41.

Colour (Fig. 4C). Very dark piceous to almost black, lateral margins of pronotum and four inconspicuous spots on the elytra reddish. Antennae, palpi and legs light reddish to dark yellowish. Lower surface dark piceous, lateral and terminal margins of abdomen reddish.

Head. Distinctly narrower than pronotum. Eyes but moderately projecting, orbits rather large, c. 1/3 of length of eye. Eyes separated from frons by a narrow furrow. Frontal furrows elongate, deep, evenly curved, almost attaining position of posterior supraorbital seta. Clypeal suture deep, clypeus quadrisetose, punctures large and deep. Labrum anteriorly straight, six-setose. Mandibles of moderate size, seta in outer scrobe elongate. Mentum with wide, obtuse, triangular tooth. Two mental setae and four gular setae very elongate. Glossa rather narrow, bisetose, paraglossae membranous, by far surpassing glossa. Lacinia elongate, sparsely spinose at inner margin. Terminal palpomeres asetose. Antenna

short, median antennomeres c. 1.5 × as long as wide. Posterior supraorbital setae situated shortly behind posterior margin of eye. Upper surface of head absolutely smooth, highly glossy.

Pronotum (Fig. 3E). Rather wide, gently cordate. Apex almost straight, apical angles barely produced. Lateral margins evenly curved, in front of base gently sinuate, base straight. Basal angles angulate, almost rectangular. Marginal sulcus anteriorly narrow, widened towards base. Both, apex and base not margined. Median line fine, not attaining apex nor base. Basal grooves deep, linear. Anterior transversal sulcus barely indicated, basal transverse sulcus shallow. Base with few scattered punctures. Both marginal setae present, the anterior one situated slightly in front of middle, the posterior one at basal angle. Surface absolutely smooth, highly glossy.

Elytra (Fig. 3F). Short and wide, convex, rather quadrate. Humeri wide, evenly rounded, lateral margin anteriorly gently convex. Base completely bordered. Scutellar stria interrupted, scutellar pore and seta present, situated in 1st interval. Four inner striae well impressed, coarsely punctate, striae shortened towards base and apex. Outer striae increasingly superficial, finely punctate. Inner intervals considerably convex. Dorsal puncture conspicuous, at inner margin of 3rd interval, situated slightly in front of middle. Marginal series consisting of 7-8 anterior and 6 posterior setae that are widely separated in middle. At end of 3rd and 5th intervals with a short seta each. Intervals absolutely smooth, highly glossy.

Lower surface. Metepisternum short, even wider than long. terminal abdominal sternite in male bisetose, in female quadrisetose.

Legs. Fairly elongate. Squamosity of male anterior tarsus unknown.

Male genitalia. Unknown.

Female genitalia. As in *M. l. lewisensis.*

Variation. Only some variation of depth of elytral striae noted.

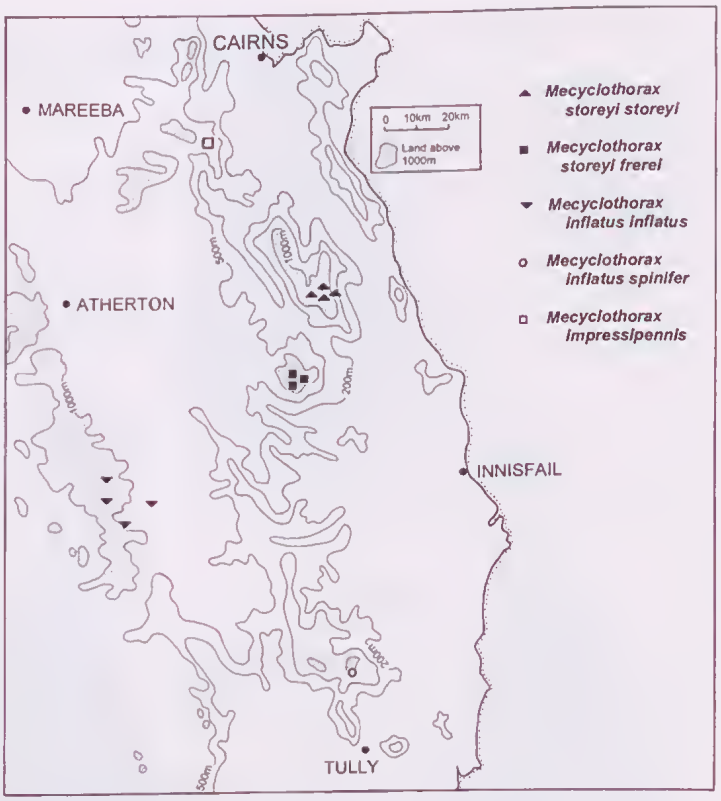

FIG. 5. Distribution of species of *Mecyclothorax* (part).

DISTRIBUTION (Fig. 5). Isley Hills, northwest of Bellenden Ker Range. Known only from type locality.

COLLECTING CIRCUMSTANCES. Collected by pyrethrum knockdown on trees and logs in upland rainforest.

Mecyclothorax inflatus sp. nov.

ETYMOLOGY. The name refers to the very wide elytra.

REMARKS. This new species is distributed through the southern and southwestern parts of Atherton Tableland. In the southernmost part of its range (Walter Hill Range) a population exists that differs by the armature of the internal sac of the male aedeagus and is described as separate subspecies. Some apparent geographic variation also occurs in the nominate subspecies with respect to external morphology (mainly in shape of pronotum). However, at the present this is not regarded as of major taxonomic value and the different populations have not been attributed

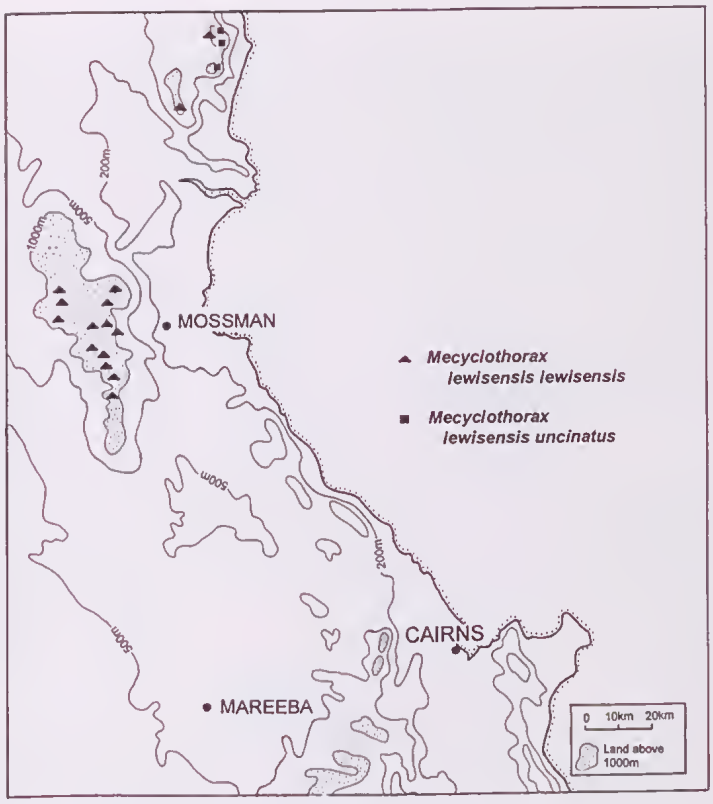

FIG. 6. Distribution of species of *Mecyclothorax* (part).

subspecific rank (see also chapter 'Variation' in the description of the nominate subspecies).

DIAGNOSIS. Small species with wide prothorax that is barely sinuate posteriorly and bears rather obtuse basal angles, clypeus quadrisetose. Further distinguished from *M. storeyi* Moore by much wider pronotum with wider base that bears the posterior marginal setae; from *M. lewisensis* Moore by wider pronotum with wider base, and by shorter genital ring; and from *M. impressipennis* sp. nov. by far less coarsely punctate elytral striae.

Mecyclothorax inflatus inflatus sp. nov.
(Figs 1E, 3H, 4D, 5)

MATERIAL. HOLOTYPE: ♂, QMT21595, Mt Father Clancy, 10km S Millaa Millaa NE Qld 4.v.1983 G. Monteith & D. K. Yeates, QM Berlesate No. 581 17.35S 145.38E Rainforest, 840m Sieved litter (QM). PARATYPES: 1 ♀, same data (QM); 2 ♂, 6 ♀, Mt Father Clancy, 9km S Millaa Millaa. 6.xii.1988 GM GT, QM Berl. 812 145.33'E 17.35'S Rf. 1000m Sieved litter. (CBM, QM); 2 ♂, 2 ♀, AUST: Qld: NE: Mt Hugh Nelson, summit 7.ii.1999 GM & DC, QM Berl. 990 17°31'S 145°33'E Rf 1200m Sieved litter (QM); 1 ♂, 3 ♀, AUST: Qld: NEQ Maalan Rd, 1.5km S Palmerston Hwy 26.xi.1994. GM, QM Berl. No. 879 17°36'S, 145.42'E Rf. 750m Sieved litter (CBM, QM); 1 ♂, 2 ♀, AUST: Qld: NE Mt Fisher, summit 8.ii.1999 GM & DC, QM Berl. 991 17°34'S 145°33'E Rf, 1360m Sieved litter (CBM, QM).

DIAGNOSIS. Distinguished from southern subspecies, *M. inflatus spinifer* subsp. nov., by slightly shorter and wider elytra and less spinose apex of internal sac of aedeagus.

DESCRIPTION. *Measurements.* Length: 2.8- 3.25mm; width: 1.35-1.65mm; Ratios. Length/width of 9th antennomere: 1.6-1.85; width/length of pronotum: 1.38-1.48; width base/apex of pronotum: 1.32-1.36; width pronotum/head: 1.49-1.65; length/width of elytra: 1.16-1.19; width elytra/pronotum: 1.34-1.40.

Colour (Fig. 4D). Head and pronotum dark piceous to almost black, elytra piceous to reddish-piceous. Lateral margins of pronotum and four very inconspicuous spots on the elytra reddish. Antennae, palpi and legs light reddish to dark yellowish. Lower surface dark piceous, lateral and terminal margins of abdomen reddish.

Head. Distinctly narrower than pronotum. Eyes but moderately projecting, orbits rather large, c. 1/3 of length of eye. Eyes separated from frons by a narrow furrow. Frontal furrows elongate, deep, evenly curved, almost attaining position of posterior supraorbital seta. Clypeal suture deep, clypeus quadrisetose, punctures large and deep. Labrum anteriorly straight, six-setose. Mandibles of moderate size, seta in outer scrobe elongate. Mentum with wide, obtuse, triangular tooth. Two mental setae and four gular setae present, very elongate. Glossa rather narrow, bisetose, paraglossae membranous, by far surpassing glossa. Lacinia elongate, sparsely spinose at inner margin. Terminal palpomeres asetose. Antenna short, median antennomeres slightly >1.5 × as long as wide. Posterior supraorbital setae situated shortly behind posterior margin of eye. Upper surface of head absolutely smooth, highly glossy.

Pronotum. Wide, barely or not cordate. Apex almost straight, apical angles barely produced. Lateral margins evenly curved, in front of base either convex or almost straight, not sinuate, base straight. Basal angles either angulate, though wide, or almost obtuse. Marginal sulcus anteriorly narrow, widened towards base. Both, apex and base not margined. Median line fine, not attaining apex nor base. Basal grooves deep, linear. Anterior transversal sulcus barely indicated, basal transverse sulcus shallow. Base with few scattered punctures. Both marginal setae present, the anterior one situated slightly in front of middle, the posterior one at basal angle. Surface absolutely smooth, highly glossy.

Elytra (Fig. 3H). Short and wide, convex, gently oviform. Humeri wide, evenly rounded, lateral margin convex throughout. Base completely bordered. Scutellar stria interrupted or almost wanting, if present, situated in 1st interval, scutellar pore and setae wanting. Inner striae including sutural stria indicated as rows of fine punctures, or even wanting, not at all impressed, outer striae not perceptible. Intervals absolutely depressed. Dorsal puncture inconspicuous, situated slightly in front of middle, at inner margin of 3rd interval when this is present. Marginal series consisting of 7-8 anterior and 6 posterior setae that are widely separated in middle. At end of 3rd and 5th intervals with a short seta each. Intervals absolutely smooth, highly glossy.

Legs. Fairly elongate. Male anterior tarsus slightly widened, asymmetrically squamose on 1st - 3rd tarsomeres.

Male genitalia (Fig. 1E). Genital ring moderately elongate, asymmetrically triangular, apex moderately wide, fairly elongate. Aedeagus normal, turned to the left side (in beetle), rather short and compact (in genus), lower surface almost straight, but suddenly curved down in front of apex. Apex short and wide, suddenly curved down and to the rear, with acute spine at end. Internal sac rather complexly folded, with a narrow elongate spine-shaped sclerotized plate within. On left side of bottom and on right side at roof of (inverted) internal sac with a rather small spinose field each. Parameres fairly dissimilar, left comparatively stout, with rather short, tapering, spine-like apex, with a single short apical seta. Right paramere narrow and elongate, with tapering apex, with 2 apical setae, 8-10 rather elongate setae along lower margin, and 2-5 shorter setae on apical third of upper margin.

Female genitalia. As in *M. l. lewisensis.*

Variation. Some geographical variation of relative shape of pronotum can be noted between the populations recorded from Mt Fisher and Mt Hugh Nelson (both near Millaa Millaa) and those from Mt Father Clancy and Malaan Rd near Palmerston Hwy, further southeast. The examined specimens from Mt Fisher and Mt Hugh Nelson possess large pronota with the lateral margins evenly curved towards the obtuse basal angles, whereas in the available specimens from Mt Father Clancy and Malaan Road the pronotum is less voluminous and has the lateral margin little convex to almost straight near the more angulate basal angles. Further collecting in the area between may clarify the taxonomic situation. As male genitalia do not show any striking differences, for the present these populations are regarded as infrasubspecific units of no taxonomic value. Probably, they are members of a morphological cline. However, for better comparison and possible future distinction, the measurements and ratios of both populations are added below:

Mt Fisher/Mt Hugh Nelson (N = 5): Length: 3.0-3.25mm; width: 1.52-1.65mm; Ratios. Length/width of 9th antennomere: 1.7-1.85; width/length of pronotum: 1.45-1.48; width base/apex of pronotum: 1.29-1.34; width pronotum/head: 1.59-1.65; length/width of elytra: 1.16-1.17; width elytra/pronotum: 1.34-1.36.

Mt Father Clancy/Malaan Rd (N = 5): Length: 2.8-3.1mm; width: 1.35-1.52mm; Ratios. Length/width of 9th antennomere: 1.6-1.7; width/length of pronotum: 1.37-1.44; width base/apex of pronotum: 1.32-1.36; width pronotum/head: 1.49-1.58; length/width of elytra: 1.18-1.19; width elytra/pronotum: 1.35-1.40.

DISTRIBUTION (Fig. 6). Southwestern part of Atherton Tableland: Mt Fisher, Mt Hugh Nelson, Mt Father Clancy, and Malaan Road south of Palmerston Hwy., North Queensland.

COLLECTING CIRCUMSTANCES. Collected by berlese extraction from rainforest leaf litter.

Mecyclothorax inflatus spinifer sp. nov.
(Figs 1F, 3G, 5)

ETYMOLOGY. The name refers to the remarkably large spinose fields at the entrance of the internal sac of the male aedeagus.

MATERIAL. HOLOTYPE: ♂, QMT21599, NE Qld, Upper Boulder Ck via Tully 27.x.1983 Monteith, Yeates & Thompson, QM Berlesate No. 600, 17.50S 145.54E Rf,

TABLE 1. *Mecyclothorax* spp. measurements.

Species	N	body length (mm)	ratio length/ width 9th antennomere	ratio width/ length pronotum	ratio width base/apex pronotum	ratio width pronotum/ head	ratio length/ width elytra	ratio width elytra/ pronotum
M. storeyi storeyi	10	2.8-3.25	1.8-2.0	1.24-1.30	1.10-1.15	1.51-1.60	1.24-1.27	1.36-1.38
M. storeyi frerei	10	2.65-3.15	1.9-2.1	1.29-1.32	1.07-1.10	1.43-1.50	1.25-1.29	1.33-1.34
M. lewisensis lewisensis	10	2.8-3.25	1.65-1.8	1.32-1.36	1.21-1.25	1.48-1.54	1.22-1.27	1.37-1.42
M. lewisensis uncinatus	10	2.9-3.1	1.65-1.8	1.34-1.41	1.14-1.17	1.45-1.54	1.19-1.24	1.33-1.37
M. impressipennis	2	3.2	1.5	1.35-1.38	1.24-1.27	1.49-1.56	1.19-1.21	1.40-1.41
M. inflatus inflatus	10	2.8-3.25	1.6-1.85	1.38-1.48	1.32-1.36	1.49-1.65	1.16-1.19	1.34-1.40
M. inflatus spinifer	10	2.8-3.05	1.7-1.8	1.36-1.40	1.30-1.37	1.53-1.59	1.20-1.23	1.31-1.36

900m Sieved litter (QM). PARATYPES: 3 ♂, 5 ♀, same data (CBM, QM); 1 ♀, same loc., 26.x.1983 GM, DY & GT Pyr. in RF. (QM).

DIAGNOSIS. Distinguished from the northern nominate subspecies by slightly longer and narrower elytra, narrower pronotum at the average, and remarkably spinose apex of internal sac of aedeagus.

DESCRIPTION. *Measurements.* Length: 2.8-3.05mm; width: 1.35-1.48mm; Ratios. Length/width of 9th antennomere: 1.7-1.8; width/length of pronotum: 1.36-1.40; width base/apex of pronotum: 1.30-1.37; width pronotum/head: 1.53-1.59; length/width of elytra: 1.20-1.23; width elytra/pronotum: 1.31-1.36.

Colour. As in nominate subspecies, though all examined specimens with rather light coloured elytra and extremely faded pattern.

Head. As in nominate subspecies.

Pronotum (Fig. 3G). As in nominate subspecies, though pronotum generally even narrower and lateral margins posteriorly even less convex than in the Mt Father Clancy/Malaan Rd population. Therefore, basal angles angulate and distinct.

Elytra. As in nominate subspecies, though slightly longer and narrower. Scutellar pore and seta lacking. Striation extremely inconspicuous, in some specimens barely recognisable.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 1F). Very similar to those of nominate subspecies, though internal sac at end with two large, remarkably spinose fields, both situated at the right side.

Female genitalia. As in nominate subspecies.

Variation. Very little variation noted.

DISTRIBUTION (Fig. 6). Southernmost Atherton Tableland: Upper Boulder Creek area in Walter Hill Range. Known only from type locality.

COLLECTING CIRCUMSTANCES. Collected by sieving litter and by pyrethrum knockdown in upland rainforest on trees and logs. Probably this subspecies generally lives on the ground, but also in moss at the bases of rainforest trees. So far collected at 900m.

MEASUREMENTS AND RATIOS IN *MECYCLOTHORAX* SHARP

For better comparison of the species the measurements and ratios of all species and subspecies are compiled in Table 1.

REMARKS. The diversity of *Mecyclothorax* in the Wet Tropics of North Queensland is shown to be greater than previously indicated. Certainly, the various taxa of the *storeyi*-group are thoroughly distinct from those species occurring in the southern half of Australia (the *ambiguus*-group), and in part, they are very closely related *inter se*. In view of shape of aedeagus and complex armature of the internal sac in all northern taxa, these probably form a rather apotypic group within the Australian *Mecyclothorax*, but at the same time in external and genitalic morphology they show a certain grade of similarity with the species occurring in New Guinea (Baehr, 1995a, 1998, 2002e) and New Caledonia (Deuve, 1987, Baehr, pers. obs.). So, it would be conceivable that the New Guinean and New Caledonian *Mecyclothorax* (and perhaps also those occurring further north in Java and Borneo) should have been derived from ancestors that were related to the *storeyi*-stock and were coming originally from northern Queensland.

Apart from *M. storeyi* which is unique for its strange, side-inverted aedeagus and generally lack of posterior marginal prothoracic seta, the other three species are still very closely related.

This is demonstrated by the morphology of the aedeagus, the duplication of the elypeal seta, and the shape and structure of pronotum. Even the most distant taxa, *M. lewisensis* and *M. inflatus*, separated by about 100km, are still very closely related.

As with the situation in New Guinea, where in those areas that have been more extensively sampled for litter inhabiting *Mecyclothorax*, many species with rather restricted ranges exist (Baehr, 1995a, 2002c), the Wet Tropics of northern Queensland also harbours a number of taxa — most still closely related — in a restricted region. In several instances, the ranges of different taxa are spatially close. Certainly this rapid turnover of ranges is due to the low vagility of these tiny, flightless, litter inhabiting, montane beetles. Since none have been taken below 650m in North Queensland, and most are from above 1,000m, even rather unimportant creek valleys may act as significant distribution barriers.

A striking example for this range fragmentation is the distribution of populations of *M. lewisensis* in the Thornton Peak area. The more northern form (*M. lewisensis uncinatus*) occurs on a mountain block that is no more than 5km distant from Thornton Peak where the nominate form occurs, and that is only separated by the valleys of two creeks that do not descend below 500m. However, these unimportant valleys apparently are sufficient to act as significant barriers for montane, rain forest living beetles. In the same region, this barrier is corroborated by the occurrence of two different species of blind, litter-inhabiting water beetles of the genus *Terradessus* (Dytiscidae), one on each side of the valley (Brancucci & Monteith, 1996). In *Mecyclothorax* the situation is even more complex. Within the range of the northern population (*M. lewisensis uncinatus*), namely near Mt Pieter Botte, the southern nominate population apparently appears again as demonstrated by the rounded apex of the aedeagus and the very elongate genital ring in males collected on Mt Pieter Botte. This population again occurs in the immediate neighbourhood of the uncinate form on mountains near Cape Tribulation, also separated by only a minor stream valley.

So far, in the North Queensland *Mecyclothorax*, no overlapping of ranges has been detected, contrary to other genera (e.g. in *Sitaphe*). This may be evidence of a rather recent diversification of this group following recent immigration into the northern montane rain forests. The high level of phylogenetic diversification of the species, on the other hand, would suggest a longer history of *Mecyclothorax* in this area. Additional knowledge about distribution may bring more light to this question.

Teraphis Castelnau, 1867

Teraphis Castelnau, 1867: 41; Castelnau, 1868: 127; Sloane, 1898: 470; Csiki, 1929: 485; Moore, 1963: 283; Moore et al., 1987: 151.
Phersita Sloane, 1903: 591; Sloane, 1920: 156; Csiki, 1929: 485; Moore, 1963: 283; Moore et al., 1987: 151.

REMARKS. A genus of Tropopterini. Most species occur in southeastern Australia from southern New South Wales to Tasmania with a single species reaching the Macpherson Range in southern Queensland. Sloane's replacement name *Phersita* was unjustified, as Moore (1987) stated.

Teraphis helmsi (Sloane)

Drimostoma helmsi Sloane, 1890: 647.
Teraphis helmsi, Sloane, 1898: 471; Csiki, 1929: 486; Moore, 1963: 284; Moore et al., 1987: 151.

DISTRIBUTION. The single northern species of this decidedly southern genus occurs in northeastern New South Wales (type locality: Dunoon, near Lismore) and at the following localities (QM specimens) along the Macpherson Range within Queensland (east to west): Upper Tallebudgera Valley; Numinbah Arch; Mt Asplenium; Mt Huntley. It is curious that it has never been taken on the well-collected Lamington Plateau, even though it occurs to the east and west of that area.

Trephisa Moore, 1963

Trephisa Moore, 1963: 282; Moore et al., 1987: 152.

REMARKS. A genus of Tropopterini, described by Moore for a unique, small-eyed, elongate species.

Trephisa parallela Moore

Trephisa parallela Moore, 1963: 282; Moore et al., 1987: 152.

REMARKS. At the time of Moore et al. (1987) the unique species of the genus was still known only from the type locality at Binna Burra on the Lamington Plateau. An additional specimen has been collected recently by G. Monteith at Springbrook Plateau about 10km SE of Binna Burra, which belongs to the same tableland system. The species is apparently endogeous, as all five recorded specimens were collected under deeply embedded rocks.

DISTRIBUTION: Lamington and Springbrook Plateaus, southeastern Queensland.

Sitaphe Moore, 1963

Sitaphe Moore, 1963: 284; Moore et al., 1987: 150.

TYPE SPECIES. *Sitaphe rotundata* Moore, 1963, by monotypy.

DIAGNOSIS. Easily distinguished from all other Australian Tropopterini by the short, oval-shaped form, rather trapezoidal pronotum that is widest at or near the basal angles, and oviform, scarcely striate elytra. Other diagnostic characters may be taken from Moore's (1963) description of the genus.

REMARKS. Highly apotypic, known only from the Wet Tropics. All taxa of this genus live in crevices of logs and dead trees in tropical upland rain forest (G.B.Monteith, pers.comm.), and extend to the summits of the highest peaks in the region.

KEY TO THE TAXA OF THE GENUS *SITAPHE* MOORE

1. Pronotum markedly trapezoidal, at basal angles not at all incurved (Figs 8D, 9B). Bellenden Ker/Bartle Frere Ranges. . . . . *trapezicollis* sp. nov.

   Pronotum less trapezoidal, at base at least slightly ineurved (Figs 8A,B,E,G,H,J,K, 9A, 9C) 2

2. Basal angle of pronotum obtuse, without distinct dentiele, lateral margin barely incurved, pronotum very wide (ratio width/length >1.60), with wide base (ratio width base/apex >2.0) (Figs 8A, 9A). Eastern and southern fringes of Atherton Tbld: Bellenden Ker/Bartle Frere/Massey Ranges, Malbon Thompson Range, Mt Hypipamee, Mt Fisher, Millaa Millaa Falls, Mt Kooroomool . . . . . *rotundata* Moore

   Basal angle of pronotum with small denticle and more or less deep incurvation in front (Figs 8E,G,H,J,K), or basal angle rectangular and lateral margin in front straight or even slightly sinuate (Figs 8B, 9C); pronotum less wide (ratio width/length <1.60), with narrower base (ratio width base/apex <2.0) 3

3. Basal angle of pronotum rectangular and lateral margin in front straight or even slightly sinuate (Figs 8B, 9C), surface of pronotum rather depressed, base in middle remarkably impressed. Bartle Frere Range . . . . . *parvicollis* sp. nov.

   Basal angle of pronotum with small denticle and more or less deep incurvation in front (Figs 8E,G,H,J,K), surface of pronotum rather convex, base in middle less deeply impressed. 4

4. Lateral margin of pronotum near base suddenly incurved, basal angle conspicuously dentiform (Figs 8E,J). . . . 5

   Lateral margin of pronotum near base but slightly incurved, basal angle faintly denticulate (Figs 8G,H,K). 6

5. Pronotum longer and narrower, anteriorly more regularly trapezoidal (Fig. 8J); right paramere less angulate near base, more curved in apical half (Fig. 7E). Cardwell Range . . . . . *hamifera* sp. nov.

   Pronotum shorter and wider, anteriorly less trapezoidal (Fig. 8E); right paramere angulate near base, rather straight in apical half (Fig. 7F). Upper Boulder Creek area in Walter Hill Range . . . . . *incurvicollis* sp. nov.

6. Smaller species, length 4.1-4.7mm and elytra short and wide (ratio length/width < 1.15) and aedeagus and parameres short (Fig. 3A). Northeastern part of Atherton Tbld: Lambs Head, Mt Williams, Isley Hills . . . . . *minuta* sp. nov.

   Either larger species, length 4.9-5.6mm and aedeagus and parameres elongate (Fig. 7G); or length 4.6-5.3mm and elytra elongate (ratio length/width > 1.18). 7

7. Elytra shorter, laterally more parallel, less oviform (Fig. 8I); aedeagus and parameres elongate (Fig. 7G). Carbine and Windsor Tblds. . . . . *parallelipennis* sp. nov.

   Elytra longer, laterally more convex, oviform (Fig. 8L); aedeagus and parameres much shorter (Fig. 7H). Thornton Peak . . . . . *ovipennis* sp. nov.

Sitaphe rotundata Moore
(Figs 2C, 7A, 8A, 9A,D, 11)

Sitaphe rotundata Moore, 1963: 284; Moore et al. 1987: 150.

MATERIAL. HOLOTYPE: ♂, Mt Bartle Frere W. slope, Q. 3-5000', Dec. 57' Darlingtons/ *Sitaphe* gen. nov. *rotundata* sp. nov. holotype ♂ Det. B.P. Moore '63 (ANIC). PARATYPE: 1 ♀, same data/ *Sitaphe* gen. nov. *rotundata* sp. nov. paratype ♀ Det. B.P. Moore '63 (ANIC).

NEW RECORDS. 1 ♀, Bellenden Ker, 1994 Crash Site. 17°16'S 145°51'E 1.xii.1998 GM. Pyr. trees. 1325m (QM);2 ♀, Bellenden Ker Range, NQ Summit TV Stn., 1560m Oct 25-31, 1981 Earthwatch/QM, QM Berl. 372 17.16S 145.51E Rf Sieved litter (QM); 1 ♂, 1 ♀, same loc., 29 Apr-3 May, 1983 GM, DY (QM); 1 ♀, Bellenden Ker, Centre Peak Summit, 10.iv.1979 GM, QM Berl. N 12 17.16A 145.51E Rf, 1500m Stick brushings (QM); 4 ♀, Bellenden Ker Range, Cable Tower 3, 1054m Oct 17-24, 1981 Earthwatch/QM (QM); 4 ♂, same loc.,17 Oct.-5 Nov. 1981 Earthwatch/QM (CBM, QM); 3 ♂, Mt Bartle Frere, NW/Centre Peak 16 Sept. 1982, 1500m GM & SM (QM); 3 ♂, same loc., 24.ix.1981 GM & DC (QM); 2 ♀, same loc., 7-8.xi.1981, 1400-1500m Earthwatch/Qld Museum (QM); 1 ♀, Mt Bartle Frere, 0.5km N of Sth. Peak, 6-8 Nov.1981, 1500m Earthwatch/QM Pyr. (QM); 3 ♂, 2 ♀, Mt Bartle Frere, N Qld. Sth. Peak Summit, 1620m 6-8 Nov., 1981 Earthwatch/QM (QM); 1 ♀, same loc., 6-8 Nov., 1981 Earthwatch/QM Pyr. (CBM); 4 ♂, 3 ♀, same loc., 29.xi.1998. GM, DC, PB. (CBM, QM); 3 ♂, Mt Bartle Frere west face, 1000-1400m 7.x.1980 GB & SM (QM); 1 ♂, Mt Bartle Frere, N Qld. Central Ridge, 1500m 27.xii.1989 GM & SM (QM); 7 ♂, 3 ♀, NE. Q: 17°16'S 145°49'E Massey Range, 4km W of Centre Bellenden Ker 9-11.x.1991. 1250m GM, HJ & DC (CBM, QM); 3 ♀, NE. Q: 17°14'S 145°48'E Massey Range, 6km NW of Centre Bellenden Ker 11-12.x.1991. 1150m GM, HJ & DC (QM); 2 ♂, North Bell Peak, 1000m Malbon Thompson Ra., N Qld. 19-22.xi.1990, 800-900m GM & GT (QM);2 ♂, same loc., 900- 1000m, 15-16.ix.1981 GM & DC (QM);1 ♀, same loc., 13 Oct. 1982, 850-1000m GM, DY & GT (QM); 1 ♂, 1 ♀, South Bell Peak Malbon Thompson Ra., N Qld. 20-21.xi.1990, 900m GM & GT Pitfall Traps (QM); 2 ♂, 2

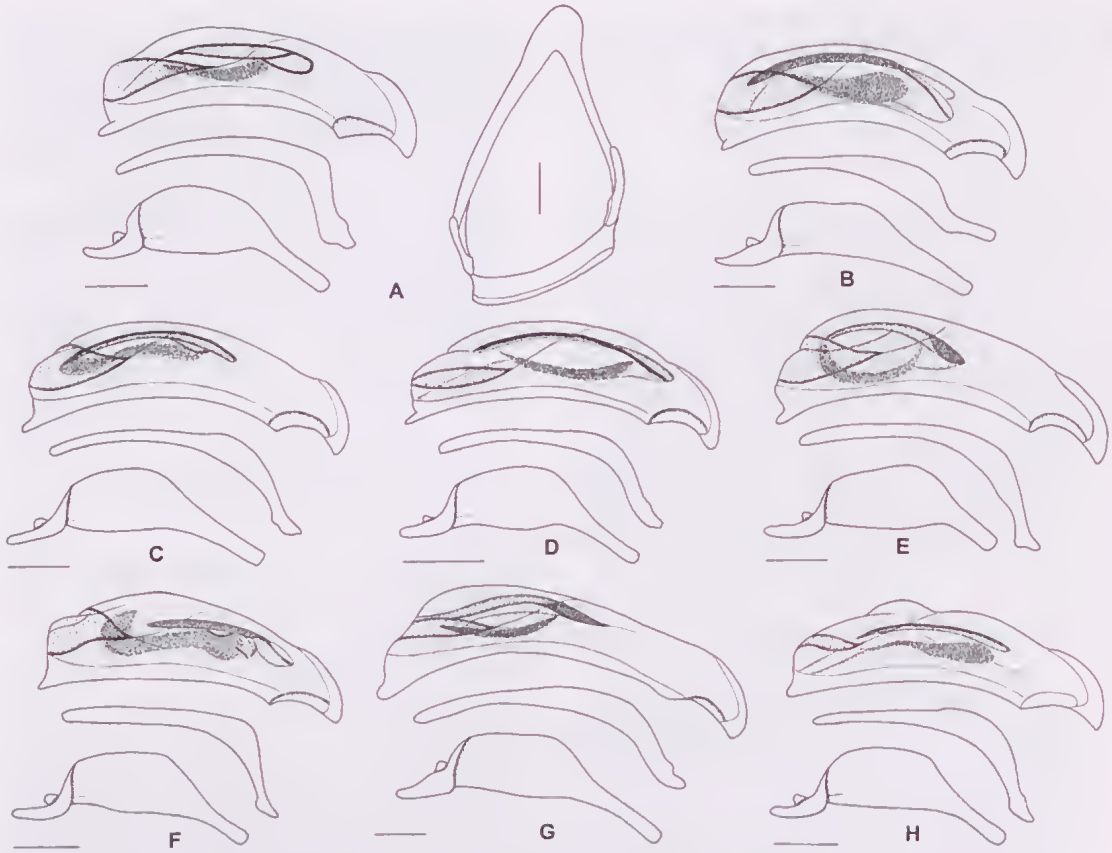

FIG. 7. Male genitalia of *Sitaphe* spp. A, *S. rotundata* Moore, aedeagus, parameres, and genital ring; B, *S. trapezicollis* sp. nov., aedeagus and parameres; C, *S. parvicollis* sp. nov., aedeagus and parameres; D, *S. minuta* sp. nov., aedeagus and parameres; E, *S. hamifera* sp. nov., aedeagus and parameres; F, *S. incurvicollis* sp. nov., aedeagus and parameres; G, *S. parallelipennis* sp. nov., aedeagus and parameres. H, *S. ovipennis* sp. nov., aedeagus and parameres. Scales: 0.5mm.

♀, Mt Hypipamee Nat. Park 5.x.1980 GM, QM Berl. 237 Rf, 950m Stiek brushing (CBM, QM); 1 ♂, same loc., 960m 24 July 1982 S. & J. Peck, SBP86, Rf streamside litter (ANIC); 1 ♂, Tower S. of Crater N P 16.v.1995 GM, QM Berl. No. 886 17°27'S, 145°29'E Rf, 1230m Stiek brushing (QM); 1 ♂, Millaa Millaa Falls, via Millaa Millaa, N Qld. 12 Aug. 1968. R. Cantrell / *Sitaphe rotundata* Mre Det. B.P. Moore'69 (QM); 1 ♂, 1 ♀, Mt Fisher, 7km SW Millaa Millaa NQ (Whiteing Road) 5.v.1983, 1200m GM, DY (QM); 3 ♂, 2 ♀, Mt Fisher, 1050-1100m 7km SW Millaa Millaa, NQ. 27-29 Apr., 1982 GM, DY & DC (CBM, QM); 1 ♂, Mt Fisher, 1/2km NW 17°33'S 145°33'E 8.ii.1999. GM 1280m. Pyr.-trees & logs, Rf. (QM); 1 ♂, Mt Fisher, summit. 1360m 17°33'S 145°33'E 8.ii.1999. Rf GM. Pyr.-trees & logs. (QM); 1 ♀, Mt Kooroomool, summit. 7km S. 17°54'S 145°41'E 3-4.xii.1998 GM DC PB 1050m, Rf. (QM).

DIAGNOSIS. Distinguished by the very wide pronotum with wide base. Further distinguished from syntopic *S. trapezicollis* sp. nov. by basally incurved lateral margins of pronotum and by the remarkably curved right paramere. Distinguished from species with similarly shaped pronota by having basal angles not sinuate and not at all angulate.

DESCRIPTION. *Measurements.* Length: 4.6-5.8mm; width: 2.40-3.25mm; Ratios. Length/width of 9th antennomere: 2.2-2.5; width/length of pronotum: 1.60-1.67; width base/apex of pronotum: 1.98-2.07; width pronotum/head: 2.02-2.12; length/width of elytra: 1.12-1.15; width elytra/pronotum: 1.25-1.30.

Colour. Overall black as in all other species.

Head. Very similar to that of other species.

Pronotum (Figs 8A, 9A). Very wide, generally trapezoidal, though lateral margins evenly

convex throughout, slightly incurved to basal angles, therefore, widest diameter at a short distance in front of basal angles. However, lateral margins not excised at basal angles which are obtuse, neither angulate, nor dentiform.

Elytra. Of average relative length, in middle rather parallel-sided though still gently convex, elytra not markedly egg-shaped. Usually two internal striae slightly depressed and rather finely punctate, both inner intervals in basal half gently convex. Outer striae decreasingly impressed or even almost absent, barely punctate.

Legs and lower surface. As in the other species.

Male genitalia (Fig. 7A). Genital ring moderately elongate, asymmetrically triangular, apex moderately wide, rather short. Aedeagus, comparatively short (in genus), lower surface gently curved. Apex very short, barely surpassing (inverted) internal sac. Orificium turned to right side. Internal sac moderately folded, with two narrow, sclerotized plates within, the upper one more spine-like, the lower one wider and near apex slightly spinose. Parameres elongate, fairly dissimilar, left comparatively stout, rather convex, with suddenly tapering, rather elongate apex, asetose. Right paramere very narrow and elongate, deeply sinuate on lower side, with tapering apex, asetose, though with a series of minute hairs at lower margin near apex.

Female genitalia (Fig. 2C). Stylomere 1 asetose at apical rim. Stylomere 2 rather short, with short apex and 2 large dentiform ventro-lateral ensiform setae of about similar size below middle of lateral margin. Near apex with a large, oblong pit and a nematiform seta originating from that pit. In middle of dorso-median surface with a large, dentiform, dorso-median ensiform seta. Lateral plate with a densely setose area at median apical margin.

DISTRIBUTION (Fig. 10). Almost the whole of Atherton Tableland and surroundings, North Queensland: Bellenden Ker and Bartle Frere Ranges, Massey Range, Malbon Thompson Range, Mt Hypipamee, Millaa Millaa Falls, Mt Fisher, Mt Kooroomool.

COLLECTING CIRCUMSTANCES. All specimens collected in montane rainforest, generally above 1050 m, with many specimens caught at the summits of the ranges. Mostly sampled by pyrethrum knockdown, but also by 'stick brushing', 'pitfall trapping' and 'on tree'. Although collecting circumstances as labelled give no clear information, this species probably lives rather on the bark or in moss of logs and trunks than in the forest litter.

Sitaphe trapezicollis sp. nov.
(Figs 7B, 8D, 9B,E, 12)

ETYMOLOGY. The name refers to the remarkably trapezoidal shape of pronotum.

MATERIAL. HOLOTYPE: ♂, QMT21669, Bellenden Ker Range, NQ Summit TV Stn., 1560m Oct. 25-31, 1981 Earthwatch/Qld Museum (QM). PARATYPES: 3 ♂, 4 ♀, same data (QM); 7 ♂, 6 ♀, same loc.,17 Oct.-Nov. 5, 1981 17.16S 145.51E Earthwatch/QM Pyr. (CBM, QM); 1 ♂, 1 ♀, same loc.Oct. 17-24, 1981 Earthwatch/QM (QM); 1 ♀, same loc., 30 Nov-2.xii.1998 HAND GM, PB& DC, 1500m 1991 (QM); 1 ♂, 1 ♀, same loc., Nov. 1-7, 1981 Earthwatch/QM, QM Berl. 342 Rf Stick brushings (QM); 1 ♂, same loc., 28.x.1983 GM. DY & GT Pyr. in RF (QM); 5 ♂, 4 ♀, same loc., 29 Apr.-3 May, 1983 GM, DY (CBM, QM); 1 ♀, same loc., 28.x.1983, GM, DY & GT (QM); 4 ♂, 2 ♀ , same loc., 28.x.1983 GM DY & GT Pyrethrum, Rf. (QM); 1 ♂, same loc., 8.x.1991. 1560m GM & HJ Pyrethrum, trees & logs (QM); 4 ♂, 2 ♀, same loc., 8.x.1991. 1560m GM, HJ & DC (QM);1 ♀, Mt Bellenden Ker, Centre Peak Summit NE Qld 10-12.iv.1979 1500m GM (QM); 2 ♂, NEQ: 17°16'S 145°51'E Bellenden Ker summit 30 Nov-2.xii.1998 HAND GM, PB & DC, 1500m 1991 (QM);7 ♂, 5 ♀, Mt Bartle Frere, N Qld. Sth. Peak Summit, 1620m 6-8 Nov., 1981 Earthwatch/QM Pyr. (CBM, QM);5 ♂, 4 ♀ , same loc., 29.xi.1998. GM. Pyrethrum, trees/logs, 1620m (CBM, QM).5 ♂, 3 ♀, same loc., 29.xi.1998, GM, DC &PB. (CBM, QM); 2 ♂, 2 ♀, Mt Bartle Frere, NW/Centre Peak ridge, 7-8 xi. 1981, 1400-1500m Earthwatch/Qld Mus. (QM); 4 ♂, 2 ♀, same loc.,16 Sept. 1982, 1500m GM & SM (QM); 2 ♂, Mt Bartle Frere, NQ 0.5km N of Sth. Peak, 6-8 Nov. 1981, 1500m Earthwatch/QM Pyr. (QM); 1 ♂, 1 ♀, 17°24'S 145°49'E Bartle Frere, Top camp 1500m, 29.xi.1998 GM, Pyr. trees, R.F.(QM).

DIAGNOSIS. Easily distinguished by the strongly trapezoid prothorax that is not at all incurved at basal angle.

DESCRIPTION. *Measurements*. Length: 4.9-6.2mm; width: 2.70-3.45mm; Ratios. Length/width of 9th antennomere: 2.25-2.5; width/length of pronotum: 1.49-1.53; width base/apex of pronotum: 2.02-2.07; width pronotum/head: 2.03-2.11; length/width of elytra: 1.12-1.13; width elytra/pronotum: 1.29-1.34.

Colour. Black, elytra in some specimens very dark piceous. Labrum and mandibles dark reddish, palpi and antennae reddish. Femora and tarsi reddish, tibiae reddish-piceous. Lower surface of anterior body dark piceous, abdomen reddish-piceous.

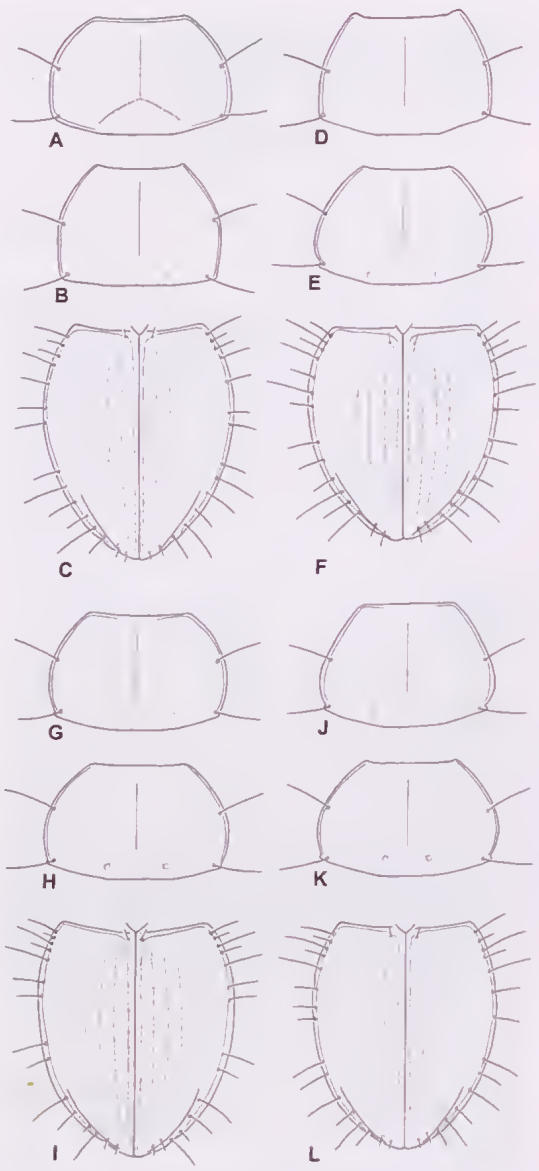

FIG. 8. Pronota and elytra of *Sitaphe* spp. A, *S. rotundata* Moore; B, C, *S. parvicollis* sp. nov.; D, *S. trapezicollis* sp. nov.; E, F, *S. incurvicollis* sp. nov.; G, *S. minuta* sp. nov.; H, I, *S. parallelipennis* sp. nov.; J, *S. hamifera* sp. nov.; K, L, *S. ovipennis* sp. nov.

Head. Half as wide as pronotum. Eyes of moderate size, little protruding, posteriorly enclosed by the orbits that are about 1/3 of length of eyes. Eyes separated from frons by a narrow, straight furrow. Frons with two elongate, curved furrows medially of eyes that are prolonged to clypeal suture. Neck separated from frons by a shallow transverse furrow. Anterior supraorbital seta situated close to eye slightly in front of middle of eye, posterior seta situated at or just behind posterior margin of eye and slightly moved on upper part of head. Clypeal suture deeply impressed. Labrum anteriorly slightly concave, 6-setose and with some shorter hairs around the anterior angles. Mandibles elongate, though of median size in genus, straight, inner margin straight for a long distance, then gently incurved, with acute apex, with elongate seta in scrobe. Right mandible with conspicuously large tooth in middle of inferior margin. Mentum with apically rounded triangular tooth. Submentum bisetose. Gula quadrisetose. Glossa short, narrow, bisetose, paraglossae hyaline, surpassing glossa. Lacinia elongate, inner margin with few strong spines, apex markedly incurved, very acute. Both palpi glabrous, maxillary palpus with elongate, fusiform terminal palpomere, labial palpus shorter and stouter, apex transverse. Antennae rather short and stout (in genus), just attaining base of pronotum, pilose from half of 4th antennomere, central antennomeres <2.5 × as long as wide. Surface of head absolutely smooth, without any indication of microsculpture or puncturation, remarkably glossy.

Pronotum (Figs 8D, 9B). Remarkably trapeziform. Wide, though comparatively narrow in genus. Apex slightly concave, anterior angles slightly produced, obtusely rounded, sides evenly though comparatively little curved, not incurved towards base, therefore widest immediately at basal angles. Base in lateral third remarkably oblique, exactly adapted to the oblique base of elytra. Basal angles angulate, not dentiform, angle c. 100°. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves very shallow, rather punctiform, situated close to middle. Both, anterior and posterior transverse sulci absent. Base in middle not impressed. Anterior lateral seta situated shortly behind middle, posterior lateral seta situated slightly inside of basal angle. Surface absolutely smooth, without any indication of microsculpture and puncturation, remarkably glossy.

Elytra. Wide, convex, considerably wider than pronotum, wide at humeri, reversely oviform. Humeri angulate, basal border deeply excised. Lateral margins convex throughout, elytra widest

at anterior fourth, than evenly narrowed. In anterior half lateral margin faintly convex, barely sinuate at position of crossing of epipleurae. Basal margin complete, lateral margin narrow throughout. Scutellar puncture and seta present, at base of outturned 1st stria. Sutural stria short, inside 1st stria. Two inner striae at least in anterior half impressed, finely punctate or even gently crenulate. External striae decreasingly less distinct, barely punctate, outer striae barely recognisable. 8th stria only in apical half present. Near apex 1st, 2nd, and in particular 7th striae well impressed, 7th stria forming an elongate, fairly deep furrow. At most 1st and 2nd intervals feebly convex in basal half, outer intervals depressed or not recognisable. Disk impunctate. Marginal series consisting of two groups of 7-8 and 6 setiferous punctures, respectively, which are rather widely separated in middle. Inside of deepened 7th stria with two additional punctures very near to apex. Some of the marginal setae very elongate. Intervals absolutely smooth, without any traces of microreticulation, highly glossy.

Lower surface. Elytral epipleurae anteriorly very wide. Metepisternum short and small, slightly longer than wide at apex. Lower surface impunctate. Terminal sternite in male bisetose, in female quadrisetose along margin, and with two shorter setae in middle somewhat removed from margin.

Legs. Fairly elongate. 5th tarsomere with one pair of very elongate setae beneath. Anterior tarsus in male barely wider than in female, 1st - 3rd tarsomeres very lightly squamose beneath. Claws large, smooth.

Male genitalia (Fig. 7B). Genital ring as in *S. rotundata*. Aedeagus as in *S. rotundata*, though even shorter and slightly more curved. Left paramere basally narrower than in *S. rotundata*, with evenly tapering apex. Right paramere less elongate than in *S. rotundata*, far less sinuate on lower side.

Female genitalia. Very similar to those of *S. rotundata*.

Variation. Some variation noted in size, relative shape of pronotum, and depth of elytral striae.

DISTRIBUTION (Fig. 11). Bellenden Ker and Bartle Frere Ranges at the eastern margin of Atherton Tableland.

COLLECTING CIRCUMSTANCES. Mostly collected by pyrethrum knockdown in upland rainforest, some also by hand collecting. Generally they have been captured not below 1500m, with most specimens collected on summit peaks and ridges. This species probably lives rather on the bark or in moss of logs and trunks than in the forest litter.

Sitaphe parvicollis sp. nov.
(Figs 7C, 8B-C, 9C,F, 12)

ETYMOLOGY. The name refers to the unusually narrow and small pronotum.

MATERIAL. HOLOTYPE: ♂, QMT21688, Mt Bartle Frere, N Qld. Sth. Peak Summit, 1620m 6-8 Nov., 1981 Earthwatch/Qld Museum Pyr. (QM). PARATYPE: 1 ♀, same loc., 29.xi.1998. GM, DC, PB (CBM).

DIAGNOSIS. Immediately distinguished by the narrower pronotum that is widest at basal third and bears almost straight lateral margins in basal third to two-fifth.

DESCRIPTION. *Measurements.* Length: 5.4-6.0mm; width: 2.75-2.95mm; Ratios. Length/width of 9th antennomere: 2.7-2.75; width/length of pronotum: 1.41; width base/apex of pronotum: 1.92; width pronotum/head: 1.93-1.95; length/width of elytra: 1.18-1.19; width elytra/pronotum: 1.35-1.37.

Colour. As in *S. trapezicollis*.

Head. As in *S. trapezicollis*, though mandibles remarkably elongate, and also antennae longer than in all other species.

Pronotum (Figs 8B, 9C). Not as trapeziform as in other species. Moderately wide, though comparatively narrow in genus. Apex slightly concave, anterior angles slightly produced, obtusely rounded, sides evenly rounded in anterior three thirds, then oblique, or even faintly concave, slightly narrowed to basal angles, not incurved at angles. Pronotum widest about at posterior two thirds. Base laterally barely oblique, slightly overlapping the gently oblique base of elytra. Basal angles angulate, very slightly produced laterally, gently dentiform. angle almost right. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves rather deep, oblique, situated close to middle. Both transverse sulci barely recognisable, though basal region in middle remarkably impressed. Anterior lateral seta situated shortly behind middle, posterior lateral seta situated slightly inside of basal angle. Surface absolutely smooth, without any

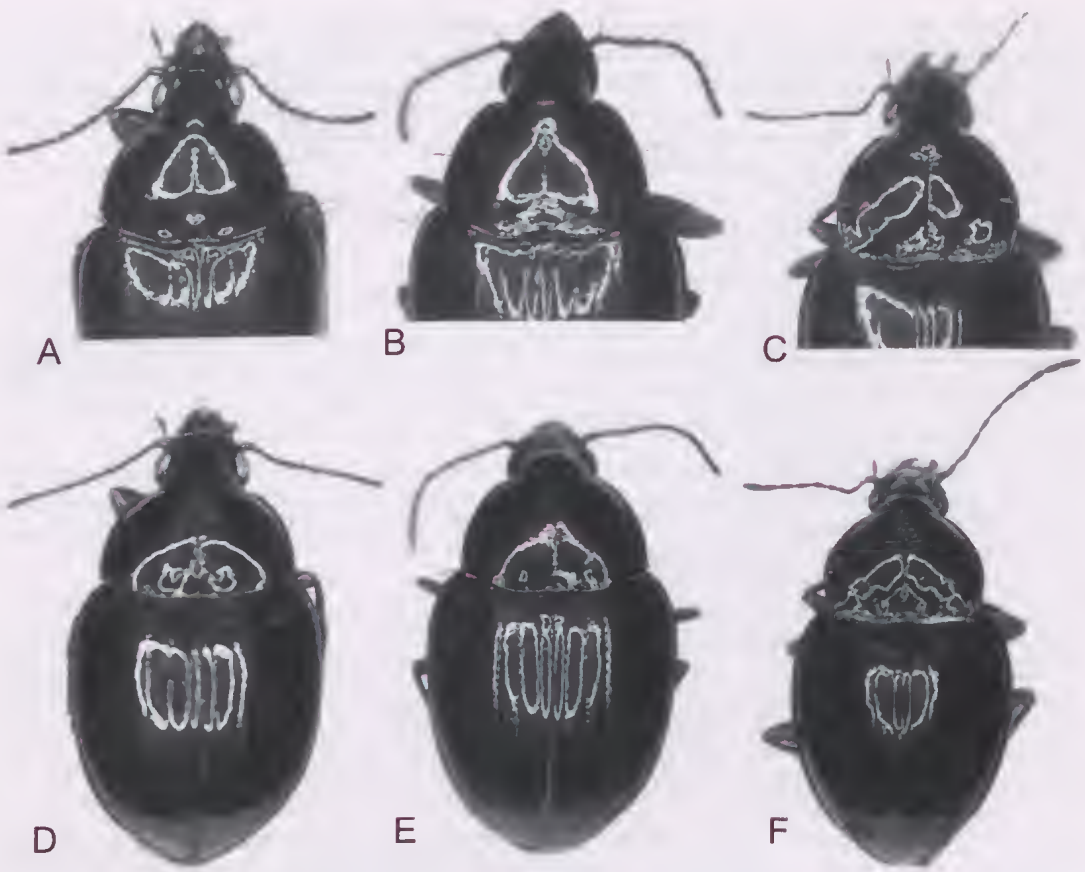

FIG. 9. Head and pronotum of *Sitaphe*. A, *S. rotundata* Moore; B, *S. trapezicollis* sp. nov.; C, *S. parvicollis* sp. nov.; habitus of *Sitaphe*: D, *S. rotundata* Moore; E, *S. trapezicollis* sp. nov.; F, *S. parvicollis* sp. nov. Lengths: 4.9mm; 5.4mm; 5.4mm.

indication of microsculpture and puncturation, remarkably glossy.

Elytra (Fig. 8C). As in *S. trapezicollis*, though longer and more regularly oviform. Base far less oblique than in other species, but otherwise rather similar. In the holotype inner striae barely impressed, outer striae barely recognisable, in the paratype at least four inner striae well impressed, intervals between clearly convex, outer striae finer but still recognisable.

Lower surface. As in *S. trapezicollis.*

Legs. As in *S. trapezicollis.*

Male genitalia (Fig. 7C). Genital ring as in *S. rotundata.* Aedeagus as in *S. rotundata*, though apex slightly longer. Left paramere very similar, but right paramere less deeply sinuate on lower surface than in *S. rotundata.*

Female genitalia. As in *S. rotundata.*

Variation. Due to scarce material little variation noted in shape, but striking variation in development and depth of elytral striae.

DISTRIBUTION (Fig. 11). South Peak of Bartle Frere Range at the eastern margin of Atherton Tableland, North Queensland.

COLLECTING CIRCUMSTANCES. Specimens were collected by hand and by pyrethrum from logs and tree trunks.

Sitaphe minuta sp. nov.
(Figs 7D, 8G, 11)

ETYMOLOGY. The name refers to the very small size of this species.

MATERIAL. HOLOTYPE: ♂, QMT21849, NEQ: 17°02'S 145°40'E Lambs Head (east end), 1180m 29.xi.1993. Monteith, Janetzki & Cook (QM). PARATYPES: 1 ♀, same data (QM); 1 ♀, Lambs Head,

10km W Edmonton, N Qld. 12-13.xii.1988, 1200m GM & GT (QM); 1 ♂, same loc., 8-9.i.1990, GM & SM (CBM); 1 ♀, same loc., 10-12.xii.1989, 1200m GM, GT & HJ (QM); 1 ♂, Isley Hills, 17°03'S 145°42'E 1050m 30.xi.1993; 1 ♀, Mt Williams, 900-1000m 16°55'S 145°40'E 2-3.xii.1993. DC, GM & HJ (QM).

DIAGNOSIS. Small, rather short species. Distinguished from the most similar species, *S. rotundata* Moore, by smaller size, narrower pronotum with relatively narrower base, distinctly incurved margin at base, and dentiform basal angles; and from likewise similar *S. ovipennis* sp. nov. by smaller size, narrower base of pronotum and considerably shorter elytra.

DESCRIPTION. *Measurements*. Length: 4.1-4.7mm; width: 2.2-2.5mm. Length/width of 9th antennomere: 1.9-2.0; width/length of pronotum: 1.52-1.56; width base/apex of pronotum: 1.81-1.86; width pronotum/head: 1.87-1.92; length/width of elytra: 1.13-1.15; width elytra/pronotum: 1.29-1.33.

Colour. As in *S. trapezicollis*.

Head. As in *S. trapezicollis*, though antennae even shorter.

Pronotum (Fig. 8G). Moderately trapeziform, because lateral margins very convex. Wide, though comparatively narrow in genus, base comparatively narrow. Apex slightly concave, anterior angles slightly produced, obtusely rounded, sides evenly curved over their whole length, considerably incurved towards base, therefore widest shortly in front of basal angles. Base in lateral third rather oblique, adapted to the oblique base of elytra. Basal angles developed as tiny denticles. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves moderate, slightly oblique, situated close to middle. Anterior transverse sulcus absent, posterior sulcus perceptible in the slightly impressed median part of base. Anterior lateral seta situated at or shortly behind middle, posterior lateral seta situated slightly inside of basal angle. Surface absolutely smooth, without any indication of microsculpture and puncturation, remarkably glossy.

Elytra. As in *S. trapezicollis*, though base slightly less oblique. Lateral margins evenly curved, elytra widest at basal fifth. Two or three inner striae distinctly impressed and finely punctate, intervals between gently convex. Outer striae decreasingly distinct, barely punctate.

Lower surface. As in *S. trapezicollis*.

Legs. As in *S. trapezicollis*.

Male genitalia (Fig. 7D). Genital ring as in *S. rotundata*. Aedeagus and parameres very much as in *S. rotundata*, though right paramere slightly shorter and less deeply sinuate.

Female genitalia. As in *S. rotundata*.

Variation. Some variation in depth and extent of puncturation of elytral striae recognised.

DISTRIBUTION (Fig. 11). Lambs Head, Mt Williams, and Isley Hills, all adjacent parts of the Lamb Range mountain massif, North Queensland.

COLLECTING CIRCUMSTANCES. This species probably also lives rather on the bark or in moss of logs and trunks than in the forest litter. All specimens were sampled above 900m, most were collected at the highest tops of the respective mountains.

Sitaphe hamifera sp. nov.
(Figs 7E, 8J, 11)

ETYMOLOGY. The name of this species refers to the dentiform basal angles of the pronotum.

TYPE MATERIAL EXAMINED. HOLOTYPE: ♂, QMT21776, Cardwell Range, NE. Qld Mt Macalister area, 1000m 19.xii.1986 Monteith, Thompson & Hamlet pyrethrum knockdown (QM).

DIAGNOSIS. Medium sized, pronotum comparatively narrow, decidedly trapeziform, with remarkably incurved lateral margins towards base, with dentiform basal angles. Further distinguished from all other species except for *S. parallelipennis* sp. nov. by rather parallel-sided, not oviform elytra. From *S. parallelipennis* it is distinguished, *inter alia*, by the narrower pronotum with comparatively wider base, and by more regularly convex lateral margins in middle of elytra.

DESCRIPTION. *Measurements*. Length: 5.2mm; width: 2.6mm; Ratios. Length/width of 9th antennomere: 2.25; width/length of pronotum: 1.47; width base/apex of pronotum: 1.98; width pronotum/head: 1.89; length/width of elytra: 1.14; width elytra/pronotum: 1.31.

Colour. As in *S. trapezicollis*.

Head. As in *S. trapezicollis*.

Pronotum (Fig. 8J). Trapeziform, because lateral margins in anterior two thirds oblique and rather straight. Comparatively narrow in genus, though base comparatively wide. Apex faintly concave,

anterior angles slightly produced, obtusely rounded, sides very little curved in anterior two thirds, then remarkably convex and deeply incurved towards base, therefore widest well in front of basal angles, almost at posterior sixth. Base laterally gently obliquely convex, rather adapted to the moderately oblique base of elytra. Basal angles developed as tiny denticles. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves deeply punctiform, obliquely extended anteriomedially, situated close to middle. Anterior transverse sulcus absent, posterior sulcus perceptible in the slightly impressed median part of base. Anterior lateral seta situated about at middle, posterior lateral seta set inside of basal angle. Surface absolutely smooth, without any indication of microsculpture and puncturation, remarkably glossy.

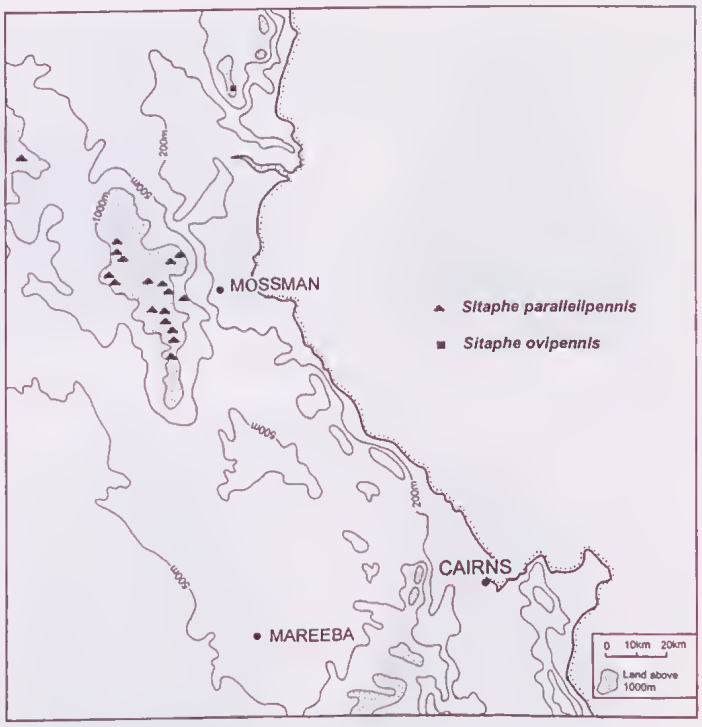

FIG. 10. Distribution of *Sitaphe* spp. (part).

Elytra. As in *S. trapezicollis*, highly convex, though shape far less oviform. Base slightly less oblique. Lateral margins more evenly curved, elytra widest about at middle, apical curvature very short. Three inner striae distinctly impressed and finely punctate, intervals between gently convex. Outer striae decreasingly distinct, barely punctate.

Lower surface. As in *S. trapezicollis*.

Legs. As in *S. trapezicollis*.

Male genitalia (Fig. 7E). Genital ring and aedeagus much as in *S. rotundata*. Left paramere with considerably shorter apex than in *S. rotundata*, right paramere slightly less deeply sinuate on lower surface.

Female genitalia. Unknown.

Variation. Unknown.

DISTRIBUTION (Fig. 12). Mt Macalister in Cardwell Range, North Queensland.

COLLECTING CIRCUMSTANCES. The holotype was collected by pyrethrum knockdown on logs or trees at 1000m, which is close to the top of this mountain.

Sitaphe incurvicollis sp. nov.
(Figs 7F, 8E,F, 12)

ETYMOLOGY. Refers to the deeply incurved lateral margins in the basal part of the pronotum.

MATERIAL. HOLOTYPE: ♂, QMT21782, Upper Boulder Creek 11km N Tully, NE Qld. 5-7 Dec 1989. 1000m Monteith, Thompson & Janetzki (QM). PARATYPES: 1 ♀, Upper Boulder Creek 6km N Tully, NE Qld. 4.xii.1989. 100-500m GM, GT & HJ (QM); 1 ♂, same loc., 650-900m, 24-27.x.1983 GM, DY & GT (QM); 2 ♀, same loc., 500-600m 24-27.x.1983 GM, DY & GT (CBM, QM); 1 ♂, Tully Falls. N Qld. 8.xii.1990, 750m GM, GT & HJ Pyr. Logs & Trees (QM); 1 ♂, Koombooloomba N Q. 1/53 GB. / M. 101. / *Sitaphe rotundata* Moore det. B.P. Moore'69 (ANIC).

DIAGNOSIS. Medium sized, rather short. Due to the basally incurved lateral margin and small, dentiform basal angle of the pronotum probably most closely related to *S. minuta* sp. nov. and *S. hamifera* sp. nov. Distinguished from *S. minuta* by larger size and wider pronotum with wider base; and from *S. hamifera* by less triangular and much wider pronotum, and by more oviform elytra the widest diameter of which is close to the

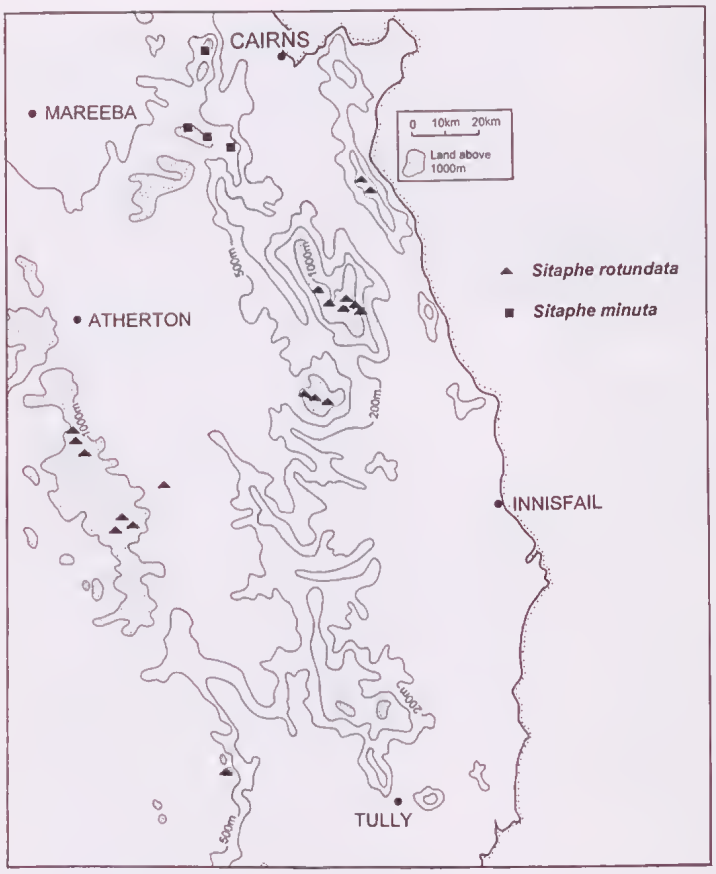

FIG. 11. Distribution of *Sitaphe* spp. (part).

humerus. From both species also distinguished by the absolutely straight apex of the right paramere.

DESCRIPTION. *Measurements.* Length: 5.0-5.4mm; width: 2.65-2.8mm. Length/width of 9th antennomere: 2.1-2.2; width/length of pronotum: 1.54-1.59; width base/apex of pronotum: 1.88-1.94; width pronotum/head: 2.02-2.09; length/width of elytra: 1.11-1.13; width elytra/pronotum: 1.28-1.31.

Colour. As in *S. trapezicollis*, though elytra distinctly piceous which colour, however, may be caused by incomplete pigmentation due to recent hatching.

Head. As in *S. trapezicollis*, though eyes slightly larger and orbits shorter.

Pronotum (Fig. 8E). Moderately trapeziform, because lateral margins rather convex. Wide, though comparatively narrow in genus, but base comparatively wide. Apex slightly concave, anterior angles slightly produced, obtusely rounded, sides evenly curved over their whole length, considerably incurved towards base, therefore widest shortly in front of basal angles. Base in lateral third rather oblique, adapted to the oblique base of elytra. Basal angles developed as tiny denticles. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves fairly deep, punctiform, obliquely extended anteriomedially, situated close to middle. Anterior transverse sulcus absent, posterior sulcus perceptible in the slightly impressed median part of base. Anterior lateral seta situated shortly behind middle, posterior lateral seta situated slightly inside of basal angle. Surface absolutely smooth, without any indication of microsculpture and puncturation, remarkably glossy.

Elytra (Fig. 8F). As in *S. trapezicollis*, though base slightly less oblique. Lateral margins rather evenly curved, elytra not markedly oviform, widest about at basal third. Three or even four inner striae distinctly impressed and finely punctate, intervals between gently convex. Outer striae decreasingly distinct, barely punctate.

Lower surface. As in *S. trapezicollis*.

Legs. As in *S. trapezicollis*.

Male genitalia (Fig. 7F). Genital ring and aedeagus as in *S. rotundata*. Left paramere with shorter apex than in *S. rotundata*, right paramere slightly shorter and with remarkably straight apex.

Female genitalia. As in *S. rotundata*.

Variation. Little variation in size and shape. Variation in depth and extent of puncturation of elytral striae recognised.

DISTRIBUTION (Fig. 12). Upper Boulder Creek at eastern end of the Walter Hill Range, to the south of the Atherton Tableland, North Queensland.

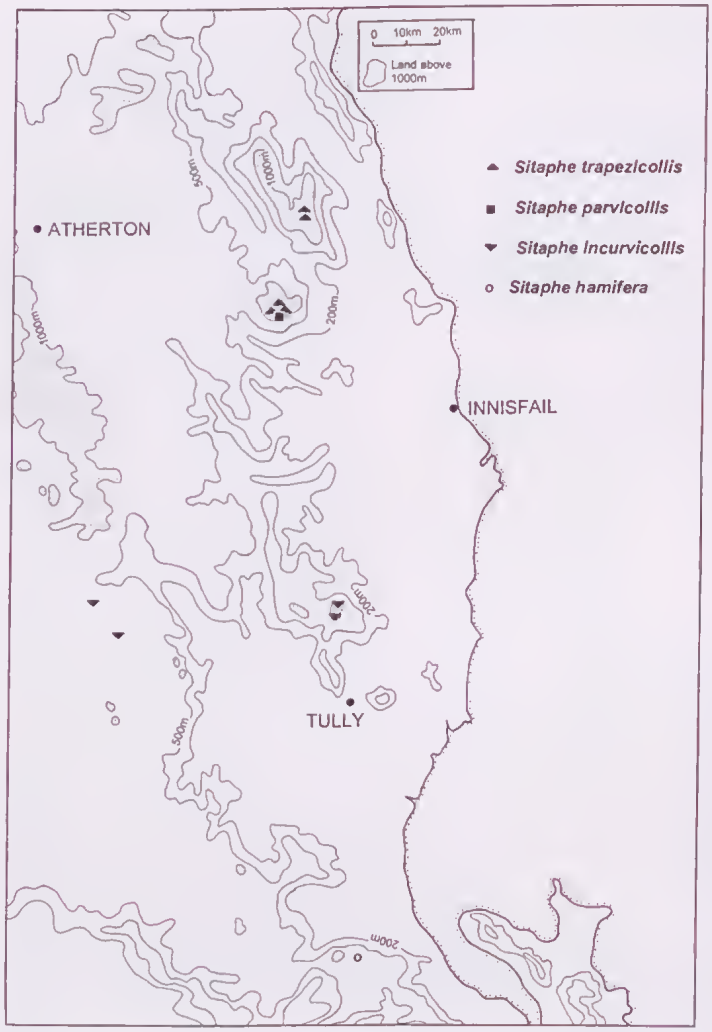

FIG. 12. Distribution of *Sitaphe* spp. (part).

COLLECTING CIRCUMSTANCES. This species probably lives on the bark or in moss of logs and trunks. Altitude records from 500-1000m, with most 500-750m. These altitudes are lower than for most other species.

Sitaphe parallelipennis sp. nov.
(Figs 7G, 8H, 8I, 10)

ETYMOLOGY. Refers to the rather parallel shape of elytra.

MATERIAL. HOLOTYPE: ♂, QMT21838, NE Qld: 16°22'S 145°13'E 7km N Mt Spurgeon (Camp 2) 17-19.x.1991. 1200-1250m Monteith, Janetzki, Cook & Roberts (QM). PARATYPES: 3 ♂, 12 ♀, same data (CBM, QM); 4 ♂, 7 ♀, Stewart Ck 4km NNE Mt Spurgeon (Camp 1), 16°24'S 145°13'E 1250-1300m 15-20.x.1991. GM, HJ, DC & LR (CBM, QM); 2 ♂, Mt Spurgeon Summit 16°26'S 145°12'E 21.xi.1997. 1320m GM, DC & Burwell (QM); 2 ♂, 2 ♀, Mt Spurgeon Summit 16°26'S 145°12'E 21.xi.1997. 1320m GM. Pyrethrum, trees & logs (QM); 1 ♂, 2km SE Mt Spurgeon 16°27'S 145°12'E 13-14.x.1991. 1100m GM, HJ & DC (QM); 2 ♂, 2 ♀, Black Mtn. 4.5km N of Mt Spurgeon. 16°24'S 145°12'E 1200-1250m 17-18.x.1991. GM, HJ, DC & LR (QM).1 ♂, Windsor Tbld, N Qld. 9.i.1989, 1225m E. Schmidt & ANZSES Site 3, Pyr.(QM); 1 ♀, same loc., 27.xii.88 - 9.i.1989 E. Schmidt & ANZSES , pitfall (QM); 2 ♀, Mt Demi, 7km SE of Mossman 29.x.1983, 1100m DY & GT Pyr. in RF. (QM); 1 ♀, Mt Demi summit, 1000m 16°30'S 145°19'S 16-17.xii.1995 GM & GT (QM); 1 ♂, Mt Lewis, Via Julatten, N Qld. 3,500-4000' 27-28.xi.1965. GM (QM); 2 ♂, 1 ♀, Mt Lewis Rd (Hut) 16°31'S 145°16'S 14 July 1996, 1200m GM (QM); 1 ♂, 2.5km N Mt Lewis, via Julatten 3.xi.1983, 1040m DY & GT Pyr. in RF. (QM); 1 ♀, Mt Lewis summit, via Julatten, 10.ix.1981 GM & DC, QM Berl. 287 Rf, 1200m Log debris (QM); 2 ♂, same loc.,via Julatten, 9.ix.1981 GM & DC (QM); 1 ♀, Mt Lewis Rd end, 10km N Mt Lewis, N Qld. 25.xi.1990. 1100m. GM, GT, DC, RS & HJ (QM); 2 ♀, 5.5km N of Mt Lewis, via Julatten 1100m, 8.ix.1981 GM & DC (QM); 2 ♀, Hilltop, 18km N Mt Lewis 16°30'S 145°16'E 23.xi.1998 GM. Pyr. trees. 1300m, RF.(QM); 1 ♂, Carbine Tbld, NE Qld Plane Crash Site 27-28.xi.1990, 1330m GM, GT, DC, RS & HJ Pitfall Traps & Hand (QM); 1 ♀, Nr Plane Crash 11km NW Mossman, N Qld 28.xii.1989, 1240m ANZSES, Pyr.(QM); 1 ♀, Devil's Thumb 12km NW Mossman, N Qld 27.xii.1989, 1000m ANZSES, Pyr.(QM); 4 ♂, 6 ♀, Devils Thumb area, 10km NW Mossman 9-10 Oct. 1982, 1000-1180m GM, DY & Thomson (CBM, QM);1 ♀, Pauls Luck, Platypus Ck, 13km W Mossman, N Qld. 1-2.i.1990, 1100m ANZSES, Pyr.(QM); 1 ♂, Mossman Bluff Summit 10km W Mossman, N Qld. 18.xii.1988. 1300m GM & GT Pyrethrum, Trees & Rocks (QM); 1 ♂, Mossman Bluff Track 9-10km W Mossman, NQ 21.xii.1989, 1000-1300m GM, GT, ANZSES (QM);

DIAGNOSIS. Fairly large, rather short, with basally slightly incurved lateral margins of pronotum and dentiform basal angles. Distinguished from all species with similar base

of pronotum by the remarkably elongate aedeagus and parameres. Further distinguished from *S. ovipennis* sp. nov. by shorter, parallel, and less oviform elytra.

DESCRIPTION. *Measurements.* Length: 4.9-5.6mm; width: 2.6-2.9mm. Length/width of 9th antennomere: 2.1-2.25; width/length of pronotum: 1.56-1.59; width base/apex of pronotum: 1.88-1.93; width pronotum/head: 1.97-2.01; length/width of elytra: 1.13-1.15; width elytra/pronotum: 1.26-1.29.

Colour. As in *S. trapezicollis*.

Head. As in *S. trapezicollis*.

Pronotum (Fig. 8H). Very similar to that of *S. ovipennis*, though slightly wider.

Elytra (Fig. 8I). As in *S. trapezicollis*, though base slightly less oblique. Lateral margins anteriorly rather gently curved, shape not distinctly oviform though in middle rather parallel-sided. Elytra widest about at basal third, or even further behind, in median part lateral margins very little convex, almost straight. Three inner striae, rarely also 4th stria in part, distinctly impressed and finely punctate, intervals between gently convex. Outer striae decreasingly distinct, barely punctate.

Lower surface. As in *S. trapezicollis*.

Legs. As in *S. trapezicollis*.

Male genitalia (Fig. 7G). Genital ring as in *S. rotundata*. Aedeagus structurally as in *S. rotundata*, but much longer and narrower and with longer apex which is distinctly curved down. Both parameres considerably longer than in *S. rotundata*, left paramere also narrower, right paramere far less deeply sinuate on lower surface.

Female genitalia. As in *S. rotundata*.

Variation. Rather little variation in size and shape noted. Only some unimportant variation in depth and extent of puncturation of elytral striae recognised.

DISTRIBUTION (Fig. 10). Widespread on Carbine and Windsor Tablelands, west of Mossman, North Queensland.

COLLECTING CIRCUMSTANCES. Many specimens were collected by pyrethrum knockdown on logs and trees, single specimens also by pitfall trapping or hand collecting. This indicates that this species lives on the bark or in moss on logs and trunks. All specimens were collected above 1000m, most at or near the summits of the respective mountains or ranges.

Sitaphe ovipennis sp. nov.
(Figs 7H, 8K, 8L, 10)

ETYMOLOGY. Refers to the oviform elytra.

MATERIAL. HOLOTYPE: ♂, QMT21756, NE Qld, Thornton Peak, 11km NE Daintree, 1100-1200m 30.x.- 1 Nov., 1983 Monteith, Yeates & Thompson (QM). PARATYPES: 7 ♂, 6 ♀, same data (CBM, QM); 2 ♂, Thornton Peak via Daintree, 1000-1300m. 20-22. ix. 1981 GM & DC (QM); 8 ♂, 3 ♀, Thornton Peak, 1100-1300m via Daintree, N Qld. 24-27.ix.1984 GM & SM (CBM, QM).

DIAGNOSIS. Medium sized, elongate, with basally slightly incurved lateral margins of pronotum and dentiform basal angles. Distinguished from all species with similar base of pronotum by much longer, decidedly oviform elytra. Further distinguished from nearby *S. parallelipennis* sp. nov. by shorter aedeagus and parameres.

DESCRIPTION. *Measurements.* Length: 4.6-5.3mm; width: 2.40-2.75mm. Length/ width of 9th antennomere: 1.8-1.9; width/length of pronotum: 1.52-1.56; width base/apex of pronotum: 1.86-1.91; width pronotum/head: 1.89-1.94; length/width of elytra: 1.18-1.20; width elytra/pronotum: 1.23-1.27.

Colour. As in *S. trapezicollis*, though in most specimens elytra rather piceous which colour, however, may be caused by incomplete pigmentation due to recent hatching.

Head. As in *S. trapezicollis*.

Pronotum (Fig. 8K). Moderately trapeziform, because lateral margins rather convex. Wide, though with comparatively narrow base. Apex gently concave, anterior angles slightly produced, obtusely rounded, sides evenly curved over their whole length, moderately incurved towards base, therefore widest shortly in front of basal angles. Base in lateral third rather oblique, adapted to the oblique base of elytra. Basal angles developed as tiny denticles. Lateral borders coarsely margined, apex and base more finely margined. Lateral channel barely indicated. Median line distinct, though shallow, neither reaching apex nor base. Basal grooves deep, punctiform, obliquely extended anteriomedially, situated close to middle. Anterior transverse sulcus absent, posterior sulcus perceptible in the rather deeply impressed median part of base. Anterior lateral seta situated shortly behind middle, posterior lateral seta set slightly inside of basal angle. Surface absolutely

smooth, without any indication of microsculpture and puncturation, remarkably glossy.

Elytra (Fig. 8L). As in *S. trapezicollis*, though considerably longer and base slightly less oblique. Lateral margins rather evenly curved, shape distinctly oviform with rather elongate apex. Elytra widest about at basal fifth. Two inner striae, rarely also 3rd stria in part, distinctly impressed and finely punctate, intervals between gently convex. Outer striae decreasingly distinct, barely punctate.

Lower surface. As in *S. trapezicollis*.

Legs. As in *S. trapezicollis*.

Male genitalia (Fig. 7H). Genital ring as in *S. rotundata*. Aedeagus as in *S. rotundata*, though apex even shorter. Left paramere very similar, though apex slightly shorter than in *S. rotundata*, right paramere slightly shorter, slightly less deeply sinuate on lower surface, and apex straight.

Female genitalia. As in *S. rotundata*.

Variation. Rather little variation in size and shape noted. Only some unimportant variation in depth and extent of puncturation of elytral striae recognised.

DISTRIBUTION (Fig. 10). Thornton Peak, north of Daintree, North Queensland.

COLLECTING CIRCUMSTANCES. All specimens were hand collected, mostly from surfaces of logs and tree trunks as with all species of *Sitaphe* (G.B.Monteith, pers. comm.). This species has been collected only above 1000m on the highest part of the Thornton Peak massif.

MEASUREMENTS AND RATIOS IN *SITAPHE* MOORE

For better comparison of the species the measurements and ratios of all species are compiled in Table 2.

REMARKS. All taxa of *Sitaphe* are treated as species, because in one area three taxa, in another area two taxa are sympatric and most probably even syntopic. Slight though well distinguished differences can be noted in external structure, mainly shape and structure of pronotum, and shape of elytra. In all species, however, the male genitalia are very similar in shape and structure. Only minor differences in relative length of aedeagus and parameres, shape of apex of aedeagus, and shape and curvature of the parameres have been noted.

Probably some of the allopatric taxa here regarded as species could be as well described as subspecies, but in view of the still unsatisfactory knowledge of the number of existing taxa and of their distribution I have decided to rate all taxa as species, because it may be conceivable that even more taxa possess overlapping ranges. Nevertheless, it should be stressed that in areas where two or three taxa occur sympatrically, the morphological divergence generally is greater than between allopatric taxa. This is not too surprising, because there must be some ecological divergence in sympatric or even syntopic taxa which, as a consequence, certainly will cause more striking morphological differences.

PHYLOGENY AND BIOGEOGRAPHY

Since all existing taxa of *Sitaphe*, and their respective ranges, are probably not yet known, any considerations about phylogenetic relations and biogeographical history of the species are necessarily provisional. Nevertheless, some considerations are possible at this stage. These, however, are still very difficult to assess due to the extremely close relationship between species. Since the male genitalia are similar throughout the genus, with the only divergence being in the northern *S. parallelipennis*, which has a longer aedeagus with bent apex, only external characters are useful. But many of these are also extremely uniform throughout the genus, e.g. shape of head, length of mandibles, size of eyes, surface structure of elytra. But shape of pronotum and of elytra may be of some use. There is also the problem of determining which genus is the nearest relative of *Sitaphe*. These obstacles make any decision about apomorphy versus plesiomorphy within *Sitaphe* extremely difficult.

Character states unique for the whole genus *Sitaphe* are the elongate mandibles, depressed eyes, wide, more or less conspicuously trapezoidal pronotum, wide and short, dorsally convex, oval-shaped elytra, reduction of elytral striae, and absence of any microreticulation or puncturation on the surface. However, as stated above, most of these character states are uniform throughout the genus. All species possess short antennae and a remarkably trapezoidal pronotum, except for *S. parvicollis*, in which the antennae are decidedly longer and narrower and the pronotum is definitively less wide at base. In the other species the pronotum is firmly attached to the base of the elytra, and is almost as wide as the latter. In *S. parvicollis* the elytra are also comparatively longer, making this species

TABLE 2. *Sitaphe* spp. measurements.

	N	body length (mm)	ratio length/ width 9th antennomere	ratio width/ length pronotum	ratio width base/apex pronotum rotundata	ratio width pronotum/ head	ratio length/ width elytra	ratio width elytra/ pronotum
S. rotundata	10	4.6-5.8	2.2-2.5	1.60-1.67	1.98-2.07	2.02-2.12	1.12-1.15	1.25-1.30
S. trapezicollis	10	4.9-6.2	2.25-2.5	1.49-1.53	2.02-2.07	2.03-2.11	1.12-1.13	1.29-1.34
S. parvicollis	2	5.4-6.0	2.7-2.75	1.41	1.92	1.93-1.95	1.18-1.19	1.35-1.37
S. minuta	7	4.1-4.7	1.9-2.0	1.52-1.56	1.81-1.86	1.87-1.92	1.13-1.15	1.29-1.33
S. hamifera	1	5.2	2.25	1.47	1.98	1.89	1.14	1.31
S. incurvicollis	7	5.0-5.4	2.1-2.2	1.54-1.59	1.88-1.94	2.02-2.09	1.11-1.13	1.28-1.31
S. parallelipennis	10	4.9-5.6	2.1-2.25	1.56-1.59	1.88-1.93	1.97-2.01	1.13-1.15	1.26-1.29
S. ovipennis	10	4.6-5.3	1.8-1.9	1.52-1.56	1.86-1.91	1.89-1.94	1.18-1.20	1.23-1.27

generally longer and narrower than all others. When compared with other, southern tropopterine genera, it seems conceivable at the first glance, then, that this species should be most plesiotypic within the genus, at least with respect to the above character states.

This compact, smooth, convex, remarkably wedge-shaped body structure, in combination with the narrow head and elongate, stiletto-shaped mandibles, strongly suggests the 'cychriform' body shape of certain snail eating carabid groups as exemplified by the northern hemisphere *Cychrus* and certain *Carabus*. Although virtually nothing is known about foraging methods and diet of *Sitaphe*, its highly specialised body shape suggests either a similar snail eating habit in all *Sitaphe*, or a foraging method of forcing the slender forebody into crevices in the bark raking for prey and using the elongate mandibles as pincers. Both habits, in turn, could explain the highly similar shape and structure in almost all species.

S. trapezicollis has a strikingly trapezoidal pronotum, the basal angles of which are not incurved, and which is very tightly adapted to the base of the elytra. If we admit that the morphological trend within the genus is directed to a most compact, short, ovoid body shape with almost jointless adaptation of pronotum and elytra, then *S. trapezicollis* would seem most apomorphic.

All other species have the base of prothorax more or less incurved to form an obtuse (*S. rotundata)* or faintly dentiform (*S. minuta*, *S. parallelipennis*, *S. ovipennis*) or markedly dentiform basal angle (*S. incurvicollis*, *S. hamifera*). With respect to this character, *S. rotundata* probably represents the most plesiomorphic state.

However *S. parvicollis* is longer and narrower than all other species, has the basal part of pronotum remarkably deeply impressed, and also possesses distinctly longer antennae and mandibles. In combination these features give this species an even stronger 'cychriform' body shape impression than in the other species. From the speculative assumption that all *Sitaphe* eat snails we may further speculate that this special body shape in *S. parvicollis* derives from a more specialised diet and/or foraging mode, e.g. consumption of snails with narrower and deeper aperture.

If all these considerations and assumptions prove right, then *S. rotundata* would be the species that is most plesiomorphic, at least with respect to the character states considered. *Sitaphe trapezicollis* and *S. parvicollis* would be most apomorphic, *S. incurvicollis* and *S. hamifera* would be somewhat intermediate, whereas *S. minuta* and both northern species (*S. parallelipennis* and *S. ovalipennis*) would be more closely related to *S. rotundata*. However, the last two species are unique in at least one character: *S. parallelipennis* has fairly dissimilar male genitalia, and *S. ovipennis* has longer elytra than usual.

We could combine these raw assumptions about relationships with the distribution pattern of the species to get a glimpse of evolution and biogeographic history of the genus. Perhaps five assumptions can be set up:

1) There is no indication where the early stock of the genus came from, except that, as a member of an originally cool adapted group, it probably arrived from the south. The nearest relatives of *Sitaphe* live in southeastern Australia and belong to the *Theprisa-Theraphis-Phersita* complex, but

I do not know which of these three genera is closest.

2) *Sitaphe* is morphologically highly isolated, though the species within the genus are extremely closely related. This suggests that the genus, or at least its original stock, is a comparatively old element of the North Queensland rain forests but that the taxonomic radiation within the genus has probably occurred comparatively recently.

3) Based the above considerations it seems conceivable that the widespread *S. rotundata* is the most plesiotypic species and may be most similar to the original stock of the genus. More apotypic species have more restricted ranges, either in the north on Carbine Tableland (*S. parallelipennis*) and Thornton Peak (*S. ovipennis*), or in the south on Cardwell Range (*S. hamifera*) and Walter Hill Range (*S. incurvicollis*), or in the east on Mts Bellenden Ker and Bartle Frere (*S. trapezicollis*, *S. parvicollis*). Actually the eastern margin of Atherton Tableland is inhabited by four different species including *S. minuta*, that occurs on the mountains northwest of Bellenden Ker/Bartle Frere, being more closely related to *S. rotundata*.

4) The high Bellenden Ker Range (comprising Mt Bellenden Ker, Mt Bartle Frere and the Massey Range) is inhabited by three species. Over part of their ranges these three species are not only sympatric but actually syntopic and have been collected within the same fogging or sieving sample. Thus they may actually live together on the same log. Characteristically, the most plesiotypic species (*S. rotundata*) again has the widest range, since it occurs not only on Bellenden Ker and Bartle Frere, but also on the contiguous Massey Range. The more evolved *S. trapezicollis* occurs on both high peaks, whereas *S. parvicollis*, probably the most specialised species, has been found only on the summit of the highest peak, Bartle Frere.

5) It is notable, therefore, that the three sympatric species on the Bellenden Ker Range show the greatest morphological divergence in the whole genus. This is presumably the result of an ecological shift leading to more essential structural differences than usual.

If the above assumptions are correct, then we have another example of a generalised scenario of distribution patterns very similar to that recognised in some other insect groups (e.g. *Philipis* (Baehr 1995b)) in the Wet Tropics:

– One or few plesiotypic species exhibit a wide distribution over the central Wet Tropics (Atherton Tableland in the broad sense), also further to the south.

– Several or many more or less apotypic species are arranged in an almost semicircular pattern around the central region or these widespread species to the north, east, and south of it.

Meonis Castelnau, 1867

Meonis Castelnau, 1867: 69; Castelnau, 1868: 155; Csiki, 1929: 484; Moore, 1963: 288; Moore et al., 1987: 152.

DIAGNOSIS. Genus of tribe Meonini (which includes *Raphetis*). Moore et al. (1987) included five species, three of which have been so far recorded only in the northern half of New South Wales. However, the genus urgently needs revision to settle the status of synonymised taxa as well as to accommodate certain taxa that are probably yet undescribed.

Meonis ater Castelnau, 1867

Meonis ater Castelnau, 1867: 70; Castelnau, 1868: 156; Sloane, 1900: 563; Sloane, 1911: 827; Sloane, 1916: 201; Csiki, 1929: 484; Straneo, 1941: 86; Moore et al., 1987: 152.

Meonis amplicollis Sloane, 1915: 448; Sloane, 1916: 201; Csiki, 1929: 484; Straneo, 1941: 86; Moore et al., 1987: 152.

REMARKS. Provided the above synonymy is correct, this species occurs in southeastern Queensland (e.g. on Lamington Plateau) and immediately adjacent northeastern New South Wales (Clarence River area). It is a ground dwelling species that inhabits leaf litter and is also found under logs in subtropical to temperate rain forest. The elongate, porrect mandibles, cyphriform head and glabrous surface suggest molluses as the diet for this and other species of *Meonis*.

DISTRIBUTION. Southeastern Queensland and northeastern New South Wales near border.

Meonis niger Castelnau, 1867

Meonis niger Castelnau, 1867: 70; Castelnau, 1868: 156; Sloane, 1911: 826; Sloane, 1916: 201; Csiki, 1929: 484; Straneo, 1941: 86; Moore et al., 1987: 152.

DISTRIBUTION. Southeastern Queensland and adjacent northeastern New South Wales, in Queensland apparently with a slightly wider range than the preceding species.

Raphetis Moore, 1963

Raphetis Moore, 1963: 288; Moore et al., 1987: 152.

TYPE SPECIES. *Raphetis darlingtoni* Moore, 1963, by original designation.

DIAGNOSIS. Meonini. As described by Moore (1963) it is distinguished from *Meonis* by glabrous instead of setose paraglossae, spinose laciniae bearing a strong terminal hook instead of densely setose lacinae lacking the terminal hook, weakly bordered base of elytra instead of unbordered base, and a normal shaped scutellum, whereas in *Meonis* the scutellum is tiny.

In most other respects the two genera are very similar and also share the characteristic body shape, small eyes, and elongate, porrect mandibles. Even the male genitalia do not show much structural differences, apart from some minor differences of size and shape of aedeagus, and length of parameres and extent of their chaetotaxy. Female stylomeres are very uniform throughout *Raphetis*, and they only exhibit minor differences of shape and number of ensiform setae on rim of first and latero-ventral margin of second stylomere.

REMARKS. The Meonini, apart from *Raphetis*, includes only *Meonis* Castelnau in Australia. *Meonis* occurs in subtropical and cool temperate rain forests of southeastern Australia from southern New South Wales to southern Queensland. In southern Queensland, the two genera are sympatric on the Springbrook Plateau.

Moore described *R. darlingtoni* from Eungella Range west of Mackay and *R. gracilis* from the western Atherton Tableland. Until now *Raphetis* was regarded as very rare, and the two species were described from one or two specimens. Through the systematic sampling of the Queensland Museum workers 38 additional specimens are now available, mainly from four rather restricted areas: Springbrook Plateau on the Queensland/ New South Wales border; Bellenden Ker/Bartle Frere Range at the eastern slope of Atherton Tableland; the Millaa Millaa/ Mt Fisher area on the western part of Atherton Tableland (from where *R. gracilis* Moore was described); and the Carbine Tableland to the north of Atherton Tableland. The fifth area from where the genus was recorded is Eungella Plateau west of Mackay in central eastern Queensland, where *R. darlingtoni* Moore occurs. Hence the distribution seems to be very fragmented, though in view of the quite exhaustive sampling that has taken place on other intermediate mountain massifs I suspect that it may reflect the true distribution.

KEY TO THE TAXA OF *RAPHETIS* MOORE

1. Pronotum markedly cordate, deeply sinuate in front of basal angles; base little wider than apex (Figs 14ABD, 15B-C). 2

   Pronotum little cordate, barely sinuate in front of basal angles; base distinctly wider than apex (Figs 14C, 15A). Southeastern Queensland. . . . . *curta* sp. nov.

2. Pronotum laterally more convex; elytra distinctly striate, striae coarsely punctate; aedeagus suddenly curved to apex. Eungella Plateau, central eastern Queensland . . . . . *darlingtoni* Moore

   Pronotum laterally less convex; elytra barely striate, striae, when visible, impunctate; aedeagus more evenly curved to apex (Fig. 13B-F) 3

3. Apex of elytra with distinct, slightly curved spine (Fig. 14G). Mt Lewis area, southern Carbine Tbld . . *gracilis spinasa* subsp. nov.. . . . . .

   Apex of elytra not spinose, at most with tiny denticle (Fig. 14H,I). 4

4. Lower margin of aedeagus slightly sinuate near apex (Fig. 13B,D). 5

   Lower margin of aedeagus straight near apex (Fig. 13C,E,F). 6

5. Pronotum narrow, barely wider than long, relatively narrower in relation to head (Fig. 14A); elytra relatively longer (see appendix). Size generally smaller, 7.0-7.8mm. Millaa Millaa/Mt Fisher area, western part of Atherton Tbld . . . . . *gracilis gracilis* Moore

   Pronotum wider, distinctly wider than long, relatively wider in relation to head (Fig. 14B); elytra relatively shorter (see appendix). Size generally larger, 7.9-8.5mm. Bellenden Ker/Bartle Frere Range, eastern margin of Atherton Tbld . . . . . *gracilis frerei* subsp. nov.

6. Apex of elytra with tiny denticle (Fig. 14I); eyes smaller, <2 × as long as orbits; pronotum narrower (see appendix). Plane Crash Site at eastern margin, and Mt Spurgeon at western margin of Carbine Tbld . *gracilis subarmata* subsp. nov. . . . . .

   Apex of elytra without denticle, regularly convex (Fig. 14J); eyes larger, well >2 × as long as orbits; pronotum wider (see appendix). Area north of Mt Spurgeon at western margin of Carbine Tbld . . *gracilis spurgeani* subsp. nov.

Raphetis darlingtoni Moore, 1963 (Fig. 16)

Raphetis darlingtoni Moore, 1963: 288; Moore et al., 1987: 153.

MATERIAL. HOLOTYPE: ♂, Eungella Rge. W. of Mackay Q 2-3000' Nov57 Darlingtons/ *Raphetis* gen.n. *darlingtoni* sp.n. holotype ♂ Det. B.P. Moore '63 (ANIC).

REMARKS. The descriptions of *R. darlingtoni* and *R. gracilis* Moore, are brief and hence contain some mistakes. The elytra are not free in *R. darlingtoni*, but are fused as in *R. gracilis*. In the holotype, however, they are opened, because the abdomen had been removed. Separating of the normally fused elytra also has been observed in preserved specimens of *R. gracilis*.

The parameres are not dissimilar in *R. darlingtoni* and similar in *R. gracilis*, but are dissimilar in both species, though slightly less so in *R. gracilis*, because the left paramere is less wide and less triangular in the latter species. Moreover, the right paramere is as well setose on its lower margin in *R. gracilis* as it is in *R. darlingtoni*.

Hence, the two species are less different in certain respects than the descriptions indicate.

For better distinction, measurements and ratios of the holotype of *R. darlingtoni* are added below.

DIAGNOSIS. Easily distinguished by the remarkably cordate prothorax, deeply impressed elytral striae, and deeply curved aedeagus with elongate, blade-like apex.

DESCRIPTION. *Measurements*. Length: 6.1mm; width: 2.55mm. Length eye/orbit: 3.2; width/length of pronotum: 1.17; width base/apex of pronotum: 1.15; width pronotum/head: 1.55; length/width of elytra: 1.37; width elytra/pronotum: 1.35.

DISTRIBUTION (Fig. 16). Eungella Plateau west of Mackay, central eastern Queensland. Known only from type locality. This species has not been recaptured since description.

Raphetis curta sp. nov.
(Figs 2D, 13A, 14C,F, 15A,D, 16)

ETYMOLOGY. Refers to the short, compact hind body compared with the other species.

MATERIAL. HOLOTYPE: ♂,QMT93419, SEQ: 28°15'S 153°16'E Springbrook Repeater, 21 Dec 1996. 1000m G.B. Monteith Pyrethrum, dead trees (QM). PARATYPES: 1 ♂, same loc., GM, Pyr. Tree trunks, 1000m (CBM); 1 ♀, same loc., 9.XII.1972 GM. & SM / *Raphetis* sp. n. det. B.P. Moore '74 (QM).

DIAGNOSIS. Easily distinguished by the barely cordate prothorax, short abdomen, and shorter and wider, on lower margin distinctly bisinuate, aedeagus.

DESCRIPTION. *Measurements*. Length: 5.3-5.7mm; width: 2.3-2.6mm. Length eye/ orbit: 2.3-2.4; width/length of pronotum: 1.20- 1.23; width base/apex of pronotum: 1.34-1.40; width pronotum/head: 1.51-1.58; length/width of elytra: 1.31-1.35; width elytra/pronotum: 1.36-1.43.

Colour. Dark piceous to blackish. Lateral margin of elytra narrowly reddish. Clypeus, labrum, and mandibles reddish-piceous, palpi and antennae reddish. Femora and tarsi reddish, tibiae reddish-piceous. Lower surface of anterior body dark piceous, abdomen reddish-piceous.

Head (Fig. 15A). Considerably narrower than pronotum. Eyes comparatively large (in genus), moderately convex, laterally fairly protruding. Eyes separated from frons by a narrow, straight furrow. Frons with two irregular, slightly curved furrows medially of eyes that are prolonged to clypeal suture. Furrows medially widened to some shallow, irregular grooves, at posterior end laterally bordered by convex ridge. Anterior supraorbital seta situated close to eye near anterior border of eye, posterior seta situated well behind eye and rather moved to upper part of head. Neck separated by a shallow, transverse furrow. Clypeal suture distinct. Labrum anteriorly slightly concave, 6-setose and with some shorter hairs around the anterior angles. Mandibles elongate, straight, though shorter than in related species, inner margin straight for a long distance, then suddenly incurved, with acute apex, with elongate seta in scrobe. Mentum with acute triangular tooth. Submentum bisetose. Gula quadrisetose. Glossa short, narrow, bisetose, paraglossae hyaline, surpassing glossa. Lacinia very elongate, inner margin with few strong spines, apex markedly incurved, very acute. Both palpi glabrous, apex transverse. Antenna rather slender and elongate, surpassing base of pronotum by about two antennomeres, pilose from half of 4th antennomere, central antennomeres c. 2.5 × as long as wide. Surface of head absolutely smooth, without any indication of microsculpture, remarkably glossy.

Pronotum (Figs 14C, 15A). Wide, moderately convex, not markedly cordiform. Apex gently concave, anterior angles slightly produced, obtusely rounded, sides evenly curved, widest at middle, very weakly sinuate in basal half. Basal angles angulate, almost rectangular, angle c. 95°. Base laterally slightly oblique. Apex not margined, base laterally more or less distinctly margined. Lateral channel narrow, slightly explanate near base. Median line distinct, well impressed, neither reaching apex nor base. Basal grooves straight, rather linear, fairly deep. Both, anterior and posterior transverse sulci barely indicated. Anterior lateral seta situated slightly in front of middle, posterior lateral seta absent. Surface absolutely smooth, without any indication of microsculpture and puncturation, though near median line with some short, transverse furrows, remarkably glossy.

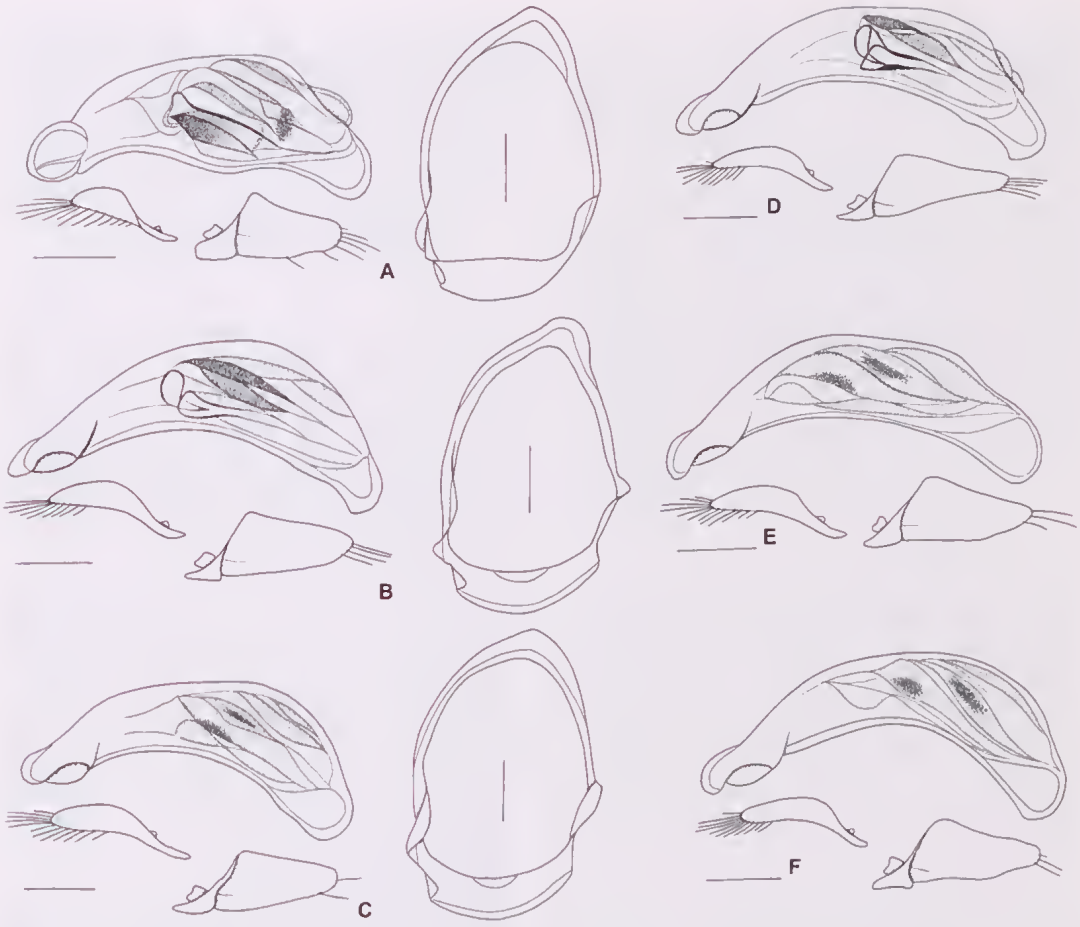

FIG. 13. Male genitalia of *Raphetis* spp. A, *R. curta* sp. nov., aedeagus, parameres, and genital ring; B, *R. gracilis gracilis* Moore, aedeagus, parameres, and genital ring; C, *R. gracilis spinosa* subsp. nov., aedeagus and parameres; D, *R. gracilis frerei* subsp. nov., aedeagus and parameres; E, *R. gracilis spurgeoni* subsp. nov., aedeagus and parameres; F, *R. gracilis subarmata* subsp. nov., aedeagus and parameres. Scales: 0.5mm.

Elytra (Fig. 14F). Wide, convex, considerably wider than pronotum, widest at humeri. Humeri gently angulate, lateral margins feebly convex, elytra widest at anterior fourth or third, than faintly though evenly narrowed. Lateral part of apex slightly sinuate at position of crossing of epipleurae, then evenly convex. Basal margin complete, lateral margin narrow throughout. Scutellary puncture and seta present, at base of 1st stria. Scutellary stria short, inside 1st stria. Striae extremely fine, barely impressed, though in one specimen 1st stria fairly distinct. External striae barely recognisable. Striae barely punctate, or internal striae very finely punctate. 8th stria complete, well impressed. Near apex 1st, 2nd, 5th, and in particular 7th striae well impressed, 7th stria forming an elongate, fairly deep furrow. Intervals depressed, at most 1st and 2nd intervals very feebly convex in apical half. Disk impunctate. Marginal series consisting of two groups of 6-7 and 6 setiferous punctures, respectively, which are widely separated in middle. Inside of deepened 7th stria with two additional punctures near apex. Some of the marginal setae very elongate. Intervals absolutely smooth, without any traces of microreticulation, highly glossy, slightly iridescent.

Lower surface. Metepisternum short, slightly longer than wide at apex. Mesepisternum and metepisternum coarsely though very sparsely punctate. Terminal sternite in male bisetose, in

female quadrisetose along margin, though with some additional shorter setae.

Legs. Fairly elongate. 5th tarsomere asetose beneath. Anterior tarsus in male barely wider than in female, 1st-3rd tarsomeres asymmetrically squamose beneath.

Male genitalia (Fig. 13A). Genital ring short and wide, asymmetrically triangular, with short, rounded apex. Aedeagus short and compact, laterally depressed, lower surface markedly bisinuate, apex short, very wide, convex, slightly turned. Internal sac rather complexly folded, with several sclerotised plates within. Both parameres comparatively short and wide, left larger than right, with wide, obtuse apex, 2-5 apical setae and 0-2 shorter setae on lower margin. Right paramere remarkably short, with acute apex and c. 12 elongate setae at apex and along the whole of lower margin.

Female genitalia (Fig. 2D). Stylomere 1 with 2 ensiform setae at middle of ventro-apical margin. Stylomere 2 rather short, with short apex and 2 large dentiform ventro-lateral ensiform setae of about similar size in middle of lateral margin. Near apex with a large, oblong pit and a short nematiform seta originating from that pit. In middle of dorso-median surface with a large, dentiform, dorso-median ensiform seta. Lateral plate with a densely setose area at median apical margin.

Variation. Some minor variation in relative shape of pronotum and elytra, depth of elytral striae and number of setae on the parameres.

DISTRIBUTION (Fig. 16). Springbrook Plateau at Queensland/New South Wales border.

COLLECTING CIRCUMSTANCES. Collected by pyrethrum knockdown in upland rainforest on 'tree trunks' and 'dead trees'. Apparently, this species lives in crevices of dead wood and, according to observations made by G. Monteith, it comes out to forage at the bark surface at night.

Raphetis gracilis Moore
(Fig. 17)

Raphetis gracilis Moore, 1963: 288; Moore et al., 1987: 153.

REMARKS. Occurs in five populations with slightly different ranges, and for the present these are classified as subspecies. For distinctions see key.

For taxonomic problems see 'Taxonomic Principles' and 'Remarks'.

DIAGNOSIS. Relatively large, easily distinguished by the combination of following character states: extremely elongate mandibles, depressed eyes, distinctly cordate prothorax, weak striation of elytra, evenly but not suddenly curved aedeagus, and rather elongate parameres the right one bearing setae only in apical part of lower rim.

Raphetis gracilis gracilis Moore
(Figs 2E, 13B, 14A, 17)

MATERIAL. HOLOTYPE: ♂, Millaa Millaa, Q. Atherton Tab. Apr. 1 '32. 2500 ft/ Australia, Harvard Exp., Darlington/ *Raphetis* gen.n. *gracilis* sp.n. holotype ♂ Det. B.P. Moore '63 (ANIC).

NEW RECORDS. 2 ♂, NEQ: 17°33'S 145°33'E Mt Fisher, ½km NW 8.ii.1999. 1280m. R/F. GM. Pyr. - trees & logs. 2170 (CBM, QM,); 1 ♂, 2 ♀, Mt Fisher, 1050-1100m 7km SW Millaa Millaa, N Qld 27-29 Apr., 1982 GM, DY & DC (QM); 2 ♂, Millaa Millaa Falls, via Millaa Millaa, N Qld 12 Aug. 1968 B. Cantrell (QM).

DIAGNOSIS. Medium sized subspecies with unarmed elytra and narrow, comparatively elongate, rather cordiform pronotum. Distinguished from the northern subspecies (*R. g. spurgeoni*, *R. g. subarmata*, *R. g. spinosa*) by narrower prothorax and narrower, on lower side slightly downcurved apex of elytra. Distinguished from most closely related *R. g. frerei* by lesser size, slightly narrower pronotum and considerably longer elytra.

REDESCRIPTION. *Measurements.* Length: 7.0-7.8mm; width: 2.65-2.90mm. Length eye/orbit: 1.8-2.0; width/length of pronotum: 1.00-1.03; width base/apex of pronotum: 1.08-1.11; width pronotum/head: 1.35-1.41; length/width of elytra: 1.49-1.52; width elytra/pronotum: 1.49-1.55.

Colour. Black. Clypeus, labrum, and mandibles reddish-piceous, palpi and antennae reddish. Legs reddish. Lower surface of anterior body dark piceous, abdomen reddish-piceous.

Head. Considerably narrower than pronotum. Eyes comparatively small (in genus), little convex, laterally little protruding. Orbits elongate, oblique, straight. Eyes separated from frons by a narrow, straight furrow. Frons with rather deep, irregularly impressed, curved furrows medially of eyes that are prolonged to clypeal suture. Furrows medially widened to shallow, irregular grooves, at posterior end laterally bordered by convex ridge. Anterior supraorbital seta situated close to eye near anterior border of eye, posterior seta situated far behind eye and rather moved to upper part of

head. Neck separated by a shallow, transverse furrow. Clypeal suture distinct. Labrum anteriorly rather deeply concave, 6-setose and with some shorter hairs around the anterior angles. Mandibles very elongate, straight, inner margin straight for a long distance, apex little curved, with elongate seta in scrobe. Mentum with acute triangular tooth. Submentum bisetose, gula quadrisetose, all setae very elongate. Glossa short, rather narrow, bisetose, paraglossae hyaline, surpassing glossa. Lacinia very elongate, inner margin with rather few strong spines, apex markedly incurved, very acute. Both palpi elongate, glabrous, apex transverse. Antenna rather slender and elongate, barely surpassing base of pronotum, pilose from apical half of 4th antennomere, central antennomeres c. 2.5 × as long as wide. Surface of head absolutely smooth, without any indication of microsculpture and puncturation, remarkably glossy.

Pronotum (Fig. 14A). Comparatively narrow, moderately convex, rather cordiform. Apex gently concave, anterior angles slightly produced, angulate, sides evenly curved, widest at middle, sinuate and almost parallel in basal fifth. Basal angles angulate, rectangular. Base laterally slightly oblique. Apex and base not margined. Lateral channel narrow, barely explanate near base. Median line distinct, slightly impressed, neither reaching apex nor base. Basal grooves straight, rather linear, fairly deep. Both transverse sulci barely indicated. Anterior lateral seta situated slightly in front of middle, posterior lateral seta absent. Surface absolutely smooth, without any indication of microsculpture or puncturation, though near median line with some short, transverse furrows, remarkably glossy.

Elytra. Comparatively elongate, convex, considerably wider than pronotum, rather parallel, wide at humeri. Humeri slightly angulate, lateral margins feebly convex, elytra widest at anterior third or near middle, posteriorly evenly narrowed. Lateral part of apex slightly sinuate at position of crossing of epipleurae, then evenly convex. Apex evenly rounded off. Basal margin complete, lateral margin narrow throughout. Scutellary puncture and seta present, at base of 1st stria. Scutellary stria not perceptible. Striae extremely fine, barely perceptible. External striae not recognisable. Striae very finely punctate. 8th stria complete, coarsely punctate, though barely impressed. Near apex only 1st and 7th striae well impressed, 7th stria forming an elongate, fairly deep furrow. Intervals absolutely depressed. Disk impunctate. Marginal series consisting of two groups of 7-8 and 6-7 setiferous punctures, respectively, which are widely separated in middle. Inside of deepened 7th stria with two additional punctures near apex. Some of the marginal setae very elongate. Intervals absolutely smooth, without any traces of microreticulation, highly glossy.

Lower surface. Metepisternum rather short, about 1.25 × as long as wide at anterior margin, considerably narrowed behind. Lower surface impunctate. Terminal sternite in male bisetose, in female quadrisetose along margin, and with two additional shorter setae in middle slightly removed from margin.

Legs. Elongate. 5th tarsomere asetose beneath. Anterior tarsus in male barely wider than in female, 1st-3rd tarsomeres asymmetrically and sparsely squamose beneath.

Male genitalia (Fig. 13B). Genital ring short and wide, asymmetrically triangular, with short, rounded apex. Aedeagus rather elongate (in genus), laterally depressed, lower surface almost evenly concave, slightly sinuate just in front of apex. Apex short, very wide, convex, though on lower side slightly angulate, slightly turned. Internal sac rather complexly folded, with several sclerotised plates within. Both parameres comparatively elongate and narrow, left larger than right, triangular, with obtusely triangular apex, and 4-5 apical setae, without additional setae on lower margin. Right paramere with acute apex and c. 10 elongate setae along the apical third of lower margin.

Female genitalia (Fig. 2E). Stylomere 1 with 3 ensiform setae at middle of ventro-apical margin, sometimes with an additional nematiform seta. Stylomere 2 moderate, with relatively short apex and 2 large dentiform ventro-lateral ensiform setae the upper one of which is considerably larger in middle of lateral margin. Near apex with a large, oblong pit and a short nematiform seta originating from that pit. In middle of dorso-median surface with a large, dentiform, dorso-median ensiform seta. Lateral plate with a densely setose area at median apical margin.

Variation. Slight differences in relative shape of pronotum and elytra.

DISTRIBUTION (Fig. 17). Millaa Millaa/Mt Fisher area in the western part of Atherton Tableland, northeastern Queensland.

COLLECTING CIRCUMSTANCES. Taken by pyrethrum knockdown on trees and logs in upland rainforest.

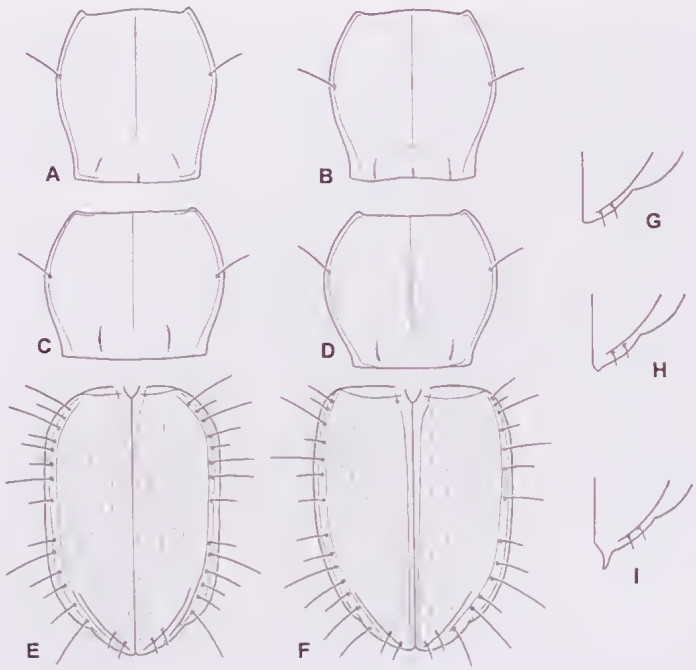

FIG. 14. Pronota, elytra and elytral apiees of *Raphetis* spp. A, *R. gracilis gracilis* Moore; B, *R. gracilis frerei* subsp. nov.; C,E, *R. curta* sp. nov.; D,F,I, *R. gracilis spurgeoni* subsp. nov.; G, *R. gracilis spinosa* subsp. nov.; H, *R. gracilis subarmata* subsp. nov.

Raphetis gracilis frerei subsp. nov.
(Figs 13D, 14B, 15B,E, 17)

ETYMOLOGY. Refers to the distribution on Mt Bartle Frere.

MATERIAL. HOLOTYPE: ♂, QMT21872, NEQ: 17°16'S 145°49'E Massey Ra., 4km W of Bellenden Ker, 1250m 10.x.1991. Pyrethrum, Monteith & Janetzki (QM). PARATYPES: 2 ♂, 1 ♀, same data (QM, CBM); 1 ♂, same locality, 11.x.1991 (QM); 2 ♀, same locality, 9-11.x.1991 (QM); 2 ♂, 1 ♀, Mt Bartle Frere. N Qld. Central Ridge. 1500m 27.xii.1989. GM Pyr. Logs (CBM, QM); 1 ♀, Bellenden Ker Range, NQ Cable Tower 3, 1054m 17 Oct.-5 Nov.1981 Earthwatch&QM (QM).

DIAGNOSIS. Large subspecies with unarmed elytra and comparatively narrow and elongate, rather cordiform pronotum. Distinguished from the northern subspecies (*R. g. spurgeoni*, *R. g. subarmata*, *R. g. spinosa*) by larger size, narrower prothorax, and narrower, on lower side slightly downcurved apex of elytra. Distinguished from most closely related *R. g. gracilis* by larger size, slightly wider pronotum and considerably shorter elytra.

DESCRIPTION. *Measurements.* Length: 7.9- 8.5mm; width: 3.1-3.3mm. Length eye/ orbit: 1.7-1.9; width/length of pronotum: 1.04- 1.07; width base/ apex of pronotum: 1.10-1.13; width pronotum/head: 1.46-1.51; length/width of elytra: 1.42-1.47; width elytra/pronotum: 1.54- 1.58.

Colour. As in nominate subspecies.

Head. As in nominate subspecies, though eyes even more depressed.

Pronotum (Figs 14B, 15B). As in nominate subspecies, though pronotum, at the average, slightly wider and with wider base.

Elytra. As in nominate subspecies, though slightly shorter and wider, on average laterally slightly more convex. Inner striae somewhat variable, either barely indicated as a row of extremely fine punctures, or even very gently impressed.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 13D). Much as in nominate subspecies, but aedeagus slightly longer and both parameres slightly narrower.

Female genitalia. As in nominate subspecies.

Variation. Some minor variation in relative shape of pronotum and elytra, and in distinctness of the inner elytral striae.

DISTRIBUTION (Fig. 17). Mt Bellenden Ker, Mt Bartle Frere, and Massey Range at the eastern margin of Atherton Tableland, North Queensland.

COLLECTING CIRCUMSTANCES. Taken by pyrethrum knockdown in upland rainforest on logs. Collected so far between 1050-1500m.

Raphetis gracilis spurgeoni subsp. nov.
(Figs 13E, 14D,E,I, 15C,F, 17)

ETYMOLOGY. Refers to the type locality near Mt Spurgeon.

MATERIAL. HOLOTYPE: ♂, QMT21876, NE.Q: 16°22'S 145°13'E 7km N Mt Spurgeon (Camp 2),17-19.x.1991, 1200-1250m, Monteith, Janetzki, Cook & Roberts (QM). PARATYPES: 2 ♂, 1 ♀, same data (CBM, QM).

DIAGNOSIS. Small subspecies with unarmed elytra and wide, short, moderately cordiform pronotum. Distinguished from both southern subspecies (*R. g. gracilis*, *R. g. frerei*) by wider prothorax and wider, on lower side evenly curved apex of elytra. Distinguished from most closely related *R. g. subarmata* and *R. g. spinosa* by more cordiform pronotum with comparatively narrower base, and by absolute lack of any spine or denticle at apex of elytra.

DESCRIPTION. *Measurements.* Length: 6.6-7.0mm; width: 2.55-2.7mms. Length eye/orbit: 2.1-2.3; width/length of pronotum: 1.12-1.16; width base/apex of pronotum: 1.10-1.15; width pronotum/head: 1.45-1.50; length/width of elytra: 1.48-1.50; width elytra/pronotum: 1.42-1.45.

Colour. As in nominate subspecies.

Head. As in nominate subspecies, though eyes relatively convex.

Pronotum (Figs 14D, 15C). As in nominate subspecies, though pronotum wide with fairly narrow base, hence rather cordiform.

Elytra (Figs 14E, 14I). As in nominate subspecies, but with wider, on lower side, evenly curved apex, and with inner elytral striae invariably very gently though perceptibly impressed, though barely punctate. Hence, inner intervals faintly convex.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 13E). As in nominate subspecies, but aedeagus less curved, apex larger and evenly rounded on lower border, and left paramere with only 3 setae at apex.

Female genitalia. As in nominate subspecies.

Variation. Slight variation noted in relative shape of eyes, prothorax, and elytra.

DISTRIBUTION (Fig. 17). North of Mt Spurgeon near the western edge of the Carbine Tableland, North Queensland.

COLLECTING CIRCUMSTANCES. Taken by pyrethrum knockdown on logs and tree trunks in upland rainforest above 1200m.

Raphetis gracilis subarmata subsp. nov.
(Figs 13F, 14H, 17)

ETYMOLOGY. Refers to the denticle at the apex of the elytra.

MATERIAL. HOLOTYPE: ♂, QMT21866, Carbine Tableland, NE Qld Plane Crash Site 27-28 Nov 1990, 1330m, Monteith, Thompson, Cook, Sheridan & Janetzki, Pitfall Traps & Hand (QM). PARATYPES: 1 ♂, 1 ♀, same data (CBM); 1 ♂, 16°24'S 145°13'E Stewart Ck, 4km NNE. Mt Spurgeon (Camp 1), 1250-1300m, 15-20.x.1991. GM, HJ, DC & LR (QM); 1 ♂, 16°24'S 145°12'E Black Mtn. 4.5km N of Mt Spurgeon, 1250-1330m, 17-18.x.1991. GM, HJ, DC & LR (QM).

DIAGNOSIS. Medium sized subspecies with slightly denticulate elytra and moderately wide and short pronotum. Distinguished from both southern subspecies (*R. g. gracilis*, *R. g. frerei*) by wider prothorax with wider base, and by wider, on lower side evenly curved apex of elytra. Distinguished from *R. g. spurgeoni* by less cordiform prothorax and presence of a denticle at the apex of the elytra; and from *R. g. spinosa* by narrower, slightly more cordiform pronotum, and by denticulate rather than spinose apex of elytra.

DESCRIPTION. *Measurements.* Length: 6.7-7.9mm; width: 2.65-3.1mm. Length eye/ orbit: 1.8-2.0; width/length of pronotum: 1.08- 1.10; width base/apex of pronotum: 1.14-1.18; width pronotum/head: 1.47-1.52; length/width of elytra: 1.45-1.48; width elytra/pronotum: 1.50-1.58.

Colour. As in nominate subspecies.

Head. As in nominate subspecies.

Pronotum. As in nominate subspecies, though base rather wide.

Elytra (Fig. 14H). As in nominate subspecies, though elytra rather short, laterally rather convex, and with a tiny sharply angulate or even denticulate at apex. Inner striae invariably gently though perceptibly impressed, though barely punctate. Inner intervals faintly convex.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 13F). As in nominate subspecies, but aedeagus more curved, apex larger and evenly rounded on lower border, and left paramere with only 2-3 setae at apex.

Female genitalia. As in nominate subspecies.

Variation. Some slight variation noted in size and in relative shape of eyes, prothorax, and elytra.

DISTRIBUTION (Fig. 17). Mt Spurgeon and Plane Crash Site at the western and eastern margins, respectively, of the Carbine Tableland, North Queensland.

COLLECTING CIRCUMSTANCES. Specimens from Mt Spurgeon were collected by pyrethrum knockdown in upland rainforest, those from Plane Crash Site by pitfall trapping and by hand

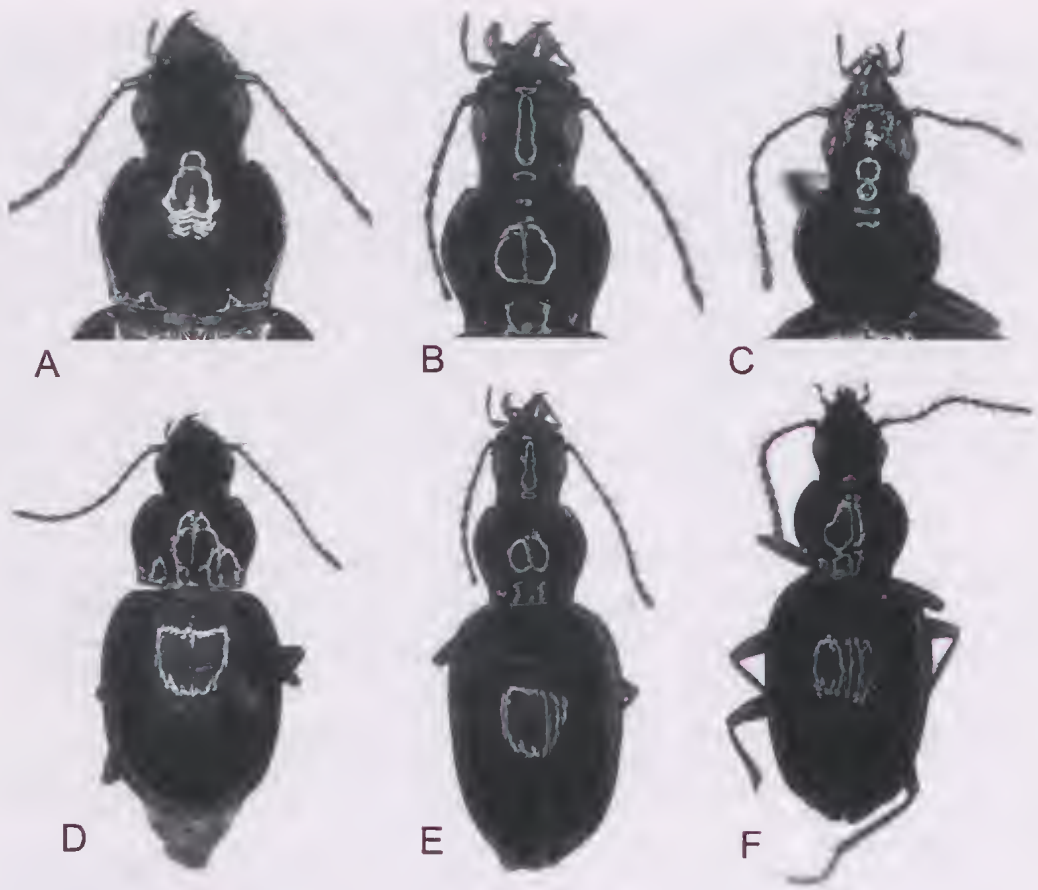

FIG. 15. Head and pronotum of *Raphetis*. A, *Raphetis curta* sp. nov.; B, *R. gracilis frerei* subsp. nov.; C, *R. gracilis spurgeoni* subsp. nov.; habitus of *Raphetis*. D, *Raphetis curta* sp. nov. E, *R. gracilis frerei* subsp. nov. F, *R. gracilis spurgeoni* subsp. nov.; lengths: 5.3mm; 8.3mm; 7.0mm.

collecting. Captured only above 1250m which is at maximum altitude on these mountains.

Raphetis gracilis spinosa subsp. nov.
(Figs 13C, 14G, 17)

ETYMOLOGY. Refers to the spinose elytral apices.

MATERIAL. HOLOTYPE: ♂, QMT21858, Mossman Bluff 10km W Mossman, N Qld. 17-18.xii.1988. 1100-1300m, Monteith & Thompson (QM). PARATYPES: 2 ♂, NEQ: 16°30'Sx145°16'E Hilltop, 18km N Mt Lewis, 23.xi.1998. GM Pyrethrum, trees. 1300m Rf. (CBM); 1 ♂, 2km SE Mt Spurgeon via Mt Carbine. N Qld. 20-21.xii.1988. 1100m, GM & GT (QM); 3 ♀, Mt Lewis Rd end 10km N Mt Lewis 25.xi.1990, 1100m, GM, RS & GT. Pyrethrum, Logs (QM).

DIAGNOSIS. Medium sized subspecies with spinose elytra and moderately wide and short pronotum with very wide base. Distinguished from both southern subspecies (*R. g. gracilis*, *R. g. frerei*) by wider prothorax with wider base, and by wider, on lower side evenly curved apex of elytra. Distinguished from both closely related *R. g. spurgeoni* and *R. g. subarmata* by less cordiform prothorax, remarkably spinose apex of the elytra, and shorter and stouter aedeagus; further on from *R. g. spurgeoni* by wider base of pronotum, and from *R. g. subarmata* by wider pronotum.

DESCRIPTION. *Measurements*. Length: 6.95-8.0mm; width: 2.6-3.2mm. Length eye/ orbit: 2.0-2.1; width/length of pronotum: 1.11- 1.16; width base/apex of pronotum: 1.18-1.22; width pronotum/head: 1.50-1.55; length/width of elytra: 1.48-1.56; width elytra/pronotum: 1.42-1.44.

Colour. As in nominate subspecies.

Head. As in nominate subspecies.

Pronotum. As in nominate subspecies, though pronotum very wide and with wide base.

Elytra (Fig. 14G). As in nominate subspecies, though elytra narrow in comparison to pronotum. Apex with conspicuous hook-shaped spine that is slightly curved outwards. Inner striae very gently impressed, barely punctate. Inner intervals not or extremely faintly convex.

Lower surface. As in nominate subspecies.

Legs. As in nominate subspecies.

Male genitalia (Fig. 13C). As in nominate subspecies, but aedeagus shorter and stouter, more evenly curved, apex larger and evenly rounded on lower border, and left paramere with only 2 setae at apex.

Female genitalia. As in nominate subspecies.

Variation. Some differences in relative shape of pronotum and elytra, and development of elytra striae.

DISTRIBUTION (Fig. 17). Mt Lewis, Mossman Bluff and Mt Spurgeon, Carbine Tableland, North Queensland.

COLLECTING CIRCUMSTANCES. Taken by pyrethrum knockdown in upland rainforest on trees and logs. Collected only above 1100m.

MEASUREMENTS AND RATIOS IN *RAPHETIS* MOORE

For better comparison of the species the measurements and ratios of all species and subspecies are compiled in Table 3.

REMARKS ON THE *RAPHETIS GRACILIS* COMPLEX

As mentioned in the introduction, the five different populations of *R. gracilis* are classified here as subspecies. At first glance, however, at least *R. gracilis spinosa* might be regarded a separate species because of its conspicuously spinose elytra and its wide pronotum with comparatively wide base. Specimens of this population also look rather different in general shape from other populations. However, the male genitalia of *R. gracilis spinosa* are not perceptibly different from those of the other populations of *R. gracilis* from the Carbine Tableland. Measurements and ratios of all five populations also widely overlap. Because of this complexity it is difficult to make reliable distinctions between populations in the present state of knowledge. On the other hand, these beetles live in rain forest at rather high altitude and a lowland barrier that is today free from rainforest exists between at least the southern populations (*R. g. gracilis* and *R. g. frerei*) and the northern populations (*R. g. spinosa*, *R. g. spurgeoni* and *R. g. subarmata)*. That these two groups are sufficiently different to be classified as separate taxa, is also indicated by the shape of the aedeagus that is slightly sinuate subapically at its lower margin in the southern group, and straight in the northern group, and by the structure of the internal sac. This particular lowland barrier is known as the Black Mountain Barrier and has been shown to be effective in several vertebrate and invertebrate groups (Schneider et al. 1998).

It is unknown how substantial the barriers were before the arrival of European settlers in north Queensland after which the tablelands between the ranges were extensively deforested. Though at least some climatic differences must have existed, even in pre-human times, that probably prevented interbreeding between the populations.

Hence, at least the southern and northern groups have been taxonomically separated for an unknown period. Within the northern group (*R. g. spinosa*, *R. g. subarmata*, and *R. g. spurgeoni*) the situation is somewhat different. All three populations live in rather close proximity, and it is even conceivable that they overlap in some areas. Moreover, the environment on the Carbine Tableland is much more homogenous today than it is on the Atherton Tableland, and this may have also been the case in pre-human times . It is conceivable, then, that these populations have differentiated rather recently, and may still be in the course of differentiation with some inter-breeding still occurring.

PHYLOGENY AND BIOGEOGRAPHY OF *RAPHETIS*. Because of comprehensive sampling by the Queensland Museum of rainforested mountains in Queensland the actual distribution of *Raphetis* is probably rather reliably known Hence, some considerations about phylogenetic relations are possible, even though new taxa may be discovered in future.

Within the Psydrinae in general and with respect to the closely related genus *Meonis* in particular, the following character states in *Raphetis* seem to be apomorphic: 1) reduction of elytral striation; 2) lengthening of head; 3) lengthening of mandibles; 4) reduction of eye size in comparison to size of orbit; 5) flattening of eyes; 6) reduction of microreticulation to get a

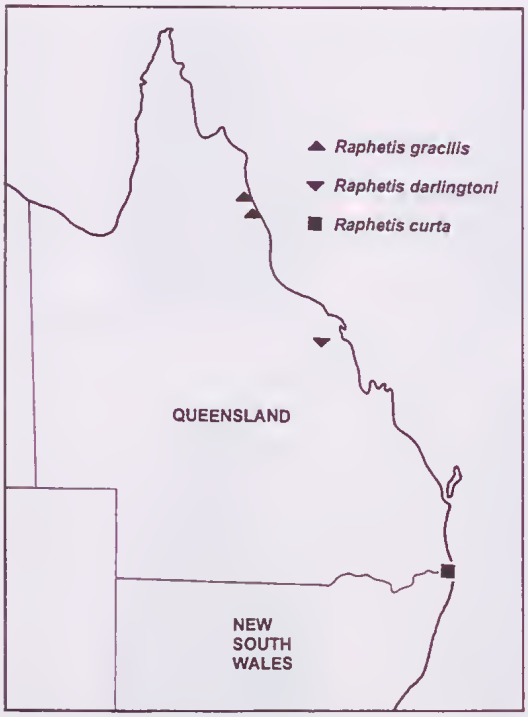

FIG. 16. Distribution of *Raphetis* spp.

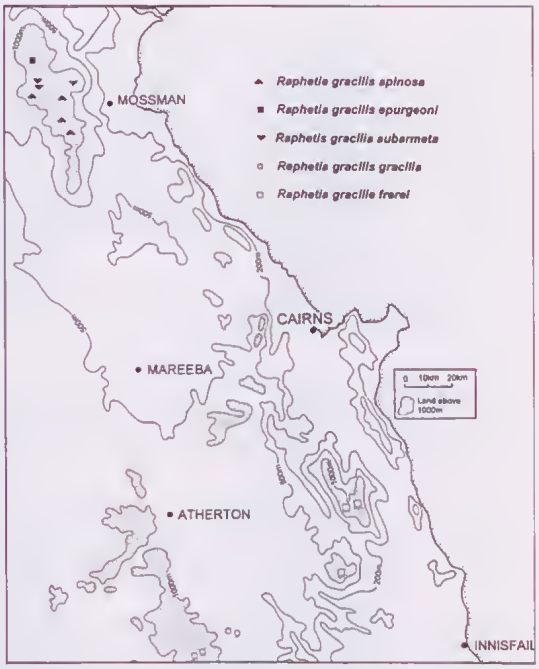

FIG. 17. Distribution of subspecies of *Raphetis gracilis* Moore in northern Queensland.

highly glossy surface; 7) reduction of pilosity on lower margin of right paramere.

These character states apply for the whole genus. But within the genus there are also strong clinal developments within most of the same characters.

When applied to the species, *R. darlingtoni* and *R. curta* are seen to be plesiomorphic in almost all characters when compared with *R. gracilis*. Only in the reduced elytral striation is *R. curta* apomorphic compared to *R. darlingtoni*, though in characters states of head, mandible, and eye size, *R. curta* is more plesiomorphic than *R. darlingtoni*. Certainly, it is not possible to draw a cladogram from the few characters used as they would not yield information about any synapomorphies between the southern species (*R. curta*, *R. darlingtoni*) and the northern *gracilis*-complex.

However, when this rough phylogenetic statement is combined with the distribution pattern of the species, it clearly reveals a clinal increase in apomorphy from south to north in several characters. Thus, the most southern species, *R. curta*, is most plesiomorphic in many respects, with *R. darlingtoni* a little more evolved, whereas *R. gracilis* of north Queensland is apomorphic in almost all character states discussed. Within the *gracilis*-complex some minor further clinal development is seen, with a south-to-north gradient also obvious in several character states. *R. g. gracilis* from Atherton Tableland, for instance, has the plesiomorphic condition of relatively large eyes and unarmed elytra. *R. g. frerei* possesses very depressed eyes, and *R. g. spinosa* has relatively convex eyes but armed elytra. The last two subspecies occur either further north on Carbine Tableland, or on the ranges at the eastern margin of Atherton Tableland.

As noted earlier, the relationships of *R. g. subarmata* and *R. g. spurgeoni* are more difficult to explain. With respect to eye size and development of spined elytra, there seems to exist a cline, but in the opposite direction to the southern populations, with the most plesiotypic *R. g. spurgeoni* in the north, and the most apotypic *R. g. spinosa* in the south. *R. g. subarmata* is intermediate in many respects.

The above distribution pattern is a scenario that has proved to be common in ground living carabids (and other taxa) of the montane rain forests of northern Queensland (e.g. Baehr,

TABLE 3. *Raphetis* spp. measurements.

	N	body length (mm)	ratio length eye/orbit	ratio width/ length pronotum	ratio width base/apex pronotum	ratio width pronotum/ head	ratio length/ width elytra	ratio width elytra/ pronotum
R. curta	3	5.3-5.7	2.3-2.4	1.20-1.23	1.34-1.40	1.51-1.58	1.31-1.35	1.36-1.43
R. darlingtoni	1	6.1	3.2	1.17	1.15	1.55	1.37	1.35
R. gracilis gracilis	8	7.0-7.8	1.8-2.0	1.00-1.03	1.08-1.11	1.35-1.41	1.49-1.52	1.49-1.55
R. gracilis frerei	10	7.9-8.5	1.7-1.9	1.04-1.07	1.10-1.13	1.46-1.51	1.42-1.47	1.54-1.58
R. gracilis spurgeoni	4	6.6-7.0	2.1-2.3	1.12-1.16	1.10-1.15	1.45-1.50	1.48-1.50	1.42-1.45
R. gracilis subarmata	5	6.7-7.9	1.8-2.0	1.08-1.10	1.14-1.18	1.47-1.52	1.45-1.48	1.50-1.58
R. gracilis spinosa	7	6.9-8.0	2.0-2.1	1.11-1.16	1.18-1.22	1.50-1.55	1.48-1.56	1.42-1.44

1995b; genus *Sitaphe*, see above). In several low vagility groups the species occurring on Atherton Tableland not only have a wide range but are usually also rather plesiotypic compared with those from Bellenden Ker/Bartle Frere ranges, Carbine Tableland and mountains tops further north. This pattern is believed to have been caused by vicarianee through separation of populations at the eastern and northern borders of a previous larger tableland following its dissection by deep river valleys and due to retreat of the rainforests to the mountain tops. Both events were caused by erosion of the uplifted tablelands into montane blocks and, at the same time, by repeated spreading and retreat of the rain forests during the stadials and interstadials of glaciation period.

Provided no contrary evidence emerges in future, this would mean that *Raphetis* probably originated somewhere in the subtropical or cool temperate rain forests of southern Queensland and later spread northwards to reach eventually the montane tropical rain forests of northern Queensland. There it passed through a considerable taxonomic radiation, presumably rather recently and probably still continuing. This scenario also agrees well with considerations about the origin of the Australian Psydrinae in general that will be developed in my forthcoming revision of the Amblytelinae (Baehr, in press).

GENERAL DISCUSSION

HABITS AND LIFE HISTORIES. Although labels do not always give information about the habits and habitats of the North Queensland psydrines, fortunately many specimens of all three genera were collected by hand. The following notes on their ecology are based on details kindly contributed by the main collector, Geoff Monteith, as summarised below. Regarding all three genera, the first generalisation that can be made is that all specimens have been collected in rainforest at medium to high altitudes and none have been taken in adjacent eucalypt-dominated open forests. Secondly, all hand-collected active individuals have been taken at night during headlight searching, so we can assume that all are nocturnal in activity.

The small species of *Mecyclothorax* live in leaf litter of upland rain forest, and are collected either by Berlese extraction of litter or by hand searching on the ground with a headlight at night. A few specimens may move a short distance up the mossy surface of tree trunks where they are occasionally sampled by pyrethrum knockdown of that situation. They appear to forage among litter at night on the ground.

Both *Sitaphe* and *Raphetis* also live in upland rain forest, generally at very high altitude and most commonly at the absolute summits of the ranges. Rarely, they are taken in leaf litter, and their primary habitat seems to be the surface or even crevices of bark or exposed dead wood. They rarely occur on living trees, but usually on dead trees and logs where there are many cracks and crevices on the surface. Specimens of *Sitaphe* usually rest in depressions and grooves on the wood or bark surface where their strong convex elytra protects them from attack. In the daytime they are usually found resting in depressions on the underside of logs and smaller pieces of wood lying on the ground. At night they run over the surface of dead wood and then they can be detected while hunting with a headlight.

Specimens of *Raphetis* are much rarer and are almost never found by hand-collecting in the daytime. They probably move into tunnels and chambers inside the dead wood in the daytime, and their more slender form also suggests such behaviour. Pyrethrum forces the beetles out from this situation when the tree trunks and log

surfaces are fogged in the daytime. At night they forage on the surface of the dead wood and almost all the hand-collected specimens are taken at night when they are doing this, sometimes on logs and sometimes on standing dead tree trunks.

So the North Queensland psydrines fall into three rather different habitat categories: *Mecyclothorax* live in leaf litter on the ground; *Sitaphe* and *Raphetis* forage on the surface of dead wood with *Raphetis* retreating inside the wood in the daytime while *Sitaphe* conceals itself in crevices on the surface.

In spite of the above information about habits of adults, nothing is known about life histories of any species, especially on their larvae which are so far unknown.

Although the strange looking body shape of *Sitaphe* and *Raphetis*, especially the narrow head and the rather elongate, porrect mandibles in both genera, indicates a specialised feeding method, there are no observations about diet or feeding habits of any *Sitaphe* or *Raphetis* species. We only can speculate about feeding and we may argue that the cychroid structure of head and mandibles could indicate that they eat snails. The very smooth, glossy surface in both genera may also corroborate this opinion.

For the northern species of *Mecyclothorax* information about diet is also lacking. Given their small size feeding on small insects or worms may be most probable, but no observations are available.

To confirm speculations about phylogenetic relations, better knowledge about ecology and ethology, and especially about life history, would be helpful.

BIOGEOGRAPHICAL CONSIDERATIONS. In *Sitaphe*, *Raphetis* and the northern species group of *Mecyclothorax*, very similar patterns of distribution can be noted. In the three genera all taxa are very closely related and most are restricted to very small ranges that repeatedly cover a single rain forest block (in the sense of Baehr 1995b) or even a single mountain top. This is a general pattern common in flightless invertebrates in the montane rain forests of the Wet Tropics of northern Queensland (Baehr, 1995b, Monteith, 1997, Davies & Lambkin, 2000, Harvey, 2000). In *Sitaphe*, however, one species occupies a fairly large range on the Atherton Tableland, which again is a common distribution pattern in the Wet Tropics.

At the first glance, the high grade of morphological similarity of the many taxa should be evidence of a very recent taxonomic radiation of rather old stocks in all three mentioned genera. There has been, however, some discussion in recent papers about the age of the many closely related invertebrate taxa occurring in the Wet Tropics, especially with regard to the montane species (e.g. Moritz et al., 2000; Russell et al., in press). In some papers evidence has been presented, mainly from molecular phylogenetic analyses (expressed in the percentage of sequence divergence of 16S rRNA), suggesting the main speciation events to be of late Tertiary age, in Pliocene or even late Miocene.

However, it seems to me rather audacious to translate such percentages of sequence divergences directly into an absolute time table, because little is known about different rates of development of molecular divergences under different or even rapidly changing environmental conditions. External morphological differences, at least can develop very rapidly when ecological factors are changing.

Hence, as a conclusion, and because molecular data are still lacking for the carabid groups mentioned herein, the high grade of morphological similarity on the background of high species diversity and a high level of endemism are still evidence of quite recent — that is Pleistocene — speciation events that most probably proceeded by allopatric speciation caused mainly by vicariance events, which apparently was a common means of evolution of diversity in tropical rain forest (Joseph et al., 1995).

During the last years when much more scrutinised collecting work was conducted in a multitude of montane rainforests of eastern and northern Queensland, a number of unexpected species of southern origin were recorded far north of the range of their relatives. Examples from ground beetles are two species of the merizodine genus *Sloaneana* in southern Queensland (Baehr, 2002b), or the occurrence of a *Tasmanitachoides* from a decidedly southerly species-group on the top of a rainforested mountain in North Queensland (Baehr, 2001), or the occurrence of about 40 species of the psydrine genera *Amblytelus* and *Dystrichothorax* in eastern and northeastern Queensland (Baehr, in press), or even the discovery of an —as yet undescribed — migadopine species in northern Queensland (G. Monteith, pers. com.), and, obviously, also the numerous species of

Mecyclothorax, *Sitaphe*, and *Raphetis* occurring in the montane rain forests of northeastern Queensland.

It should be remembered, however, that the ranges of certain decidedly northern genera also have been extended to the south due to recent sampling; as one example the first discovery of a species of northern *Philipis* in northern New South Wales (Baehr, 2002a) should be noted.

These new discoveries show that the traditional biogeographical division of the Australian biota is even less rigid than it was believed so far. In particular the geographic border between the so-called Bassian and Torresian subregions in eastern Australia that has been roughly estimated to follow about the Queensland/New South Wales border, turns out more and more to be a fiction. Even the montane regions of North Queensland include more species that originally stem from cool- or even cold-adapted southern groups, than true Torresian faunal elements. If we accept that there is a clear-cut border at all, then this border is — so to speak — rather a horizontal one that extends over a very long distance along the east coast from northern or even mid-New South Wales up to northeastern Queensland. It lies between the warmer and, in parts, drier lowlands and lower reaches of the mountains and the cooler and mostly wetter tablelands and tops of the ranges. Whereas the rain forests, swamps, ponds and large rivers of the lowlands possess a true Torresian fauna, the carabid fauna of the cooler montane tropical rain forests, *Nothofagus* forests, fern bogs, and cold streams likely could be attributed to the Bassian subregion. This Bassian faunal element along the mountain tops of eastern Australia superimposes the Torresian fauna, and it even appears again in the *Nothofagus* forests and bogs of the highlands of New Guinea.

It has been believed that the connection of the Australian block to the southeast Asian insular belt during Miocene not only resulted in the invasion of numerous Oriental species into Australia, but also that these immigrants generally were superior over the native fauna and pushed it back as they advanced to the south (e.g. Darlington, 1968). Certainly, this picture is not right, or, at least, it does not apply for the montane environments of eastern Queensland. On the contrary, it seems that at least the Pleistocene glacial period supported the evolution and taxonomic radiation of Bassian faunal elements even in the montane rainforests of North Queensland.

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FURTHER INFORMATION ON TWO PONTONIINE SHRIMPS FROM ASCIDEAN HOSTS, *DASELLA BRUCEI* BERGGREN, 1990 AND *PSEUDOPONTONIA MINUTA* (BAKER, 1907) (CRUSTACEA: DECAPODA: PALAEMONIDAE)

A.J. BRUCE

Bruce, A.J. 2003 06 30: Further information on two pontoniine shrimps from ascidian hosts, *Dasella brucei* Berggren, 1990 and *Pseudopontonia minuta* (Baker, 1907) (Crustacea: Decapoda: Palaemonidae). *Memoirs of the Queensland Museum* **49**(1): 111-114. Brisbane. ISSN 0079-8835.

Further records of two rare and little known pontoniine shrimps, *Dasella brucei* Berggren, and *Pseudopontonia minuta* (Baker) are reported from Queensland and South Australia respectively. *Dasella brucei* is previously known only from its lost holotype specimen and *Pseudopontonia minuta* has been reported on only three previous occasions. A new host record is reported for *Dasella brucei* and the host of *Pseudopontonia minuta*, the ascidian *Polycarpa flava* Kott, is identified for the first time. ❐ *Natantia, Pontoniinae, Dasella brucei, Pseudopontonia minuta, new ascidian host records, Queensland, South Australia.*

A.J. Bruce, Queensland Museum, PO Box 3300, South Brisbane, 4101 Australia (e-mail abruce@broad.net.au); 20 June 2002.

Pontoniine shrimps of the genus *Dasella* Lebour, 1945, are associates of some Indo-West Pacific ascidian hosts (Bruce, 1993). Only three species have been described, two from Australia and one from the western Indian Ocean.

In 1981, Bruce reported a male specimen of *Dasella herdmaniae* from *Herdmania momus* (Savigny) from Heron Island, Queensland. At that time *D. herdmaniae* was the only species of the genus and otherwise previously known only from the type material from Tuticorin, India. *Dasella ansoni* was described by Bruce (1983a) from the Arafura Sea in association with *Phallusia depressiuscula* Heller. Berggren (1990) reported on further specimens of *D. herdmaniae* from Moçambique and demonstrated the specimen from Heron Island was not conspecific and designated the single specimen as a new species, *D. brucei*. This specimen, which would have become the holotype of *D. brucei* was dispatched from Heron Island to the Australian Museum on 10 August 1979 but was never received and cannot now be located in the Australian Museum collections (P. Berents, 23 May 2000, pers. comm.) or elsewhere. It is therefore presumed lost. There have been no subsequent reports of this species in the literature. Recently further specimens have become available for study, considerably extending the range of this species which is still known only from Queensland waters.

Pseudopontonia minuta (Baker), was one of the earliest Australian pontoniine shrimps described and until now was one of the rarest and least known, with only the type specimens from 'South Australia' and two other specimens, both from New South Wales (Baker, 1907; Bruce, 1972, 1983b). The host animal also remained unidentified. Further material has been collected in the MAFRI Benthic Laboratory Survey of Port Adelaide harbour, which enabled the host to be identified for the first time.

The specimens are deposited in the collections of the Queensland Museum, (QMW). CL refers to the post orbital carapace length. QMGH numbers refer to the host catalogue numbers. Full details of *D. brucei* and *P. minuta* and synonymies are to be found in Li (2000) and Davie (2002)

SYSTEMATICS

Sub-phylum CRUSTACEA
Order DECAPODA Latreille, 1802
Family PALAEMONIDAE Rafinesque, 1815
Sub-family PONTONIINAE Kingsley, 1878

Dasella brucei Berggren, 1990 (Fig. 1)

Dasella herdmaniae Bruce, 1981: 50-54, figs 1-2.
Dasella brucei Berggren, 1990: 558. Chace & Bruce, 1993: 78 (key). Müller, 1993: 23, (full synonymy). Li, 2000: 42, fig. 42, (full synonymy). Davie, 2002: 309.

MATERIAL. Queensland: 1 ♀ off Murdock Point, North Queensland, 2 September 1977, 5m, QMW25502. 1 ov. ♀, Mooloolaba, 4 September 1977, 2.9-22.9m, coll. A. Rozenfelds. 1 ov. ♀, Curtin Artificial Reef, Moreton Bay, stn. 22, 27.07°S 153.22°E, 22m, 4 April 1995, coll. J. Short, QMW20466.

HOSTS. (QMW25502) in branchial sac of *Herdmania grandis* (Heller), QMGH768. (Rozenfelds

specimen and QMW20466) *Herdmania momus* (Savigny), QMGH2200, (Ascidiacea).

TYPES. As the original specimen of *D. brucei* is lost, the intact female specimen (#1, CL 2.6mm, W25502) is now designated as a neotype. Type locality: 14°36'S, 144°54'E.

REMARKS. The Murdock Point specimen is in good condition, intact, with all pereiopods. The Mooloolaba specimen is rather incomplete and in an extremely fragile condition, but agrees well with the previously published information. A single pereiopod, probably the third, with the diagnostic propod and dactyl is preserved.

Dasella brucei is distinguished from *D. herdmaniae* by the pair of normal slender tapering acute distoventral spines on the third ambulatory propod (Fig. 1B), with similar spines along the ventral border, whereas *D. herdmaniae* has a pair of small blunt distally swollen club-shaped spines distoventrally, with similar spines ventrally in these positions (Berggren, 1990).

Berggren (1990) commented on the marked ridge below the level of the mobile hepatic spine in *D. herdmaniae*. It may be noted that a similar horizontal angulation is also present in the Mooloolaba specimen of *D. brucei* (Fig. 1A) but inconspicuous in the Murdock Point specimen. The carapace in the former is therefore rather depressed, with a concavity above the lateral ridge. The Moreton Bay specimen is the largest, CL 3.25mm. In all specimens the ventral rostral tooth is obsolescent.

The fifth thoracic sternite bears a transverse carina, posterior to the second pereiopod coxae, with a small median notch. Length of undeveloped ovum, 0.5mm.

The hosts of these shrimps both belong to *Herdmania*. The Murdock Point specimen was found in *Herdmania grandis* (Heller), an endemic Australian species, and the Mooloolaba and Moreton Bay specimens in *H. momus* (Savigny), a species of widespread Indo-West Pacific distribution. *Dasella* has been found in association with three genera of ascidian host, *Herdmania* (*D. brucei*, *D. herdmaniae*), *Pyura* (*D. herdmaniae*) and *Phallusia* (*D. ansoni*).

Dasella brucei is known from three localities in Queensland waters and has not been reported from outside Queensland. *Dasella herdmaniae* has been reported from Moçambique (Berggren, 1990), southern India (Lebour, 1939) and the Philippines (Chace & Bruce, 1993). It is possible that the original Heron Island specimen of *D. brucei*, reported in association with *H. momus* (Bruce, 1981) was associated with *H. grandis*, which was considered a synonym of *H. momus* at that time, but both species of *Herdmania* occur on Heron Island.

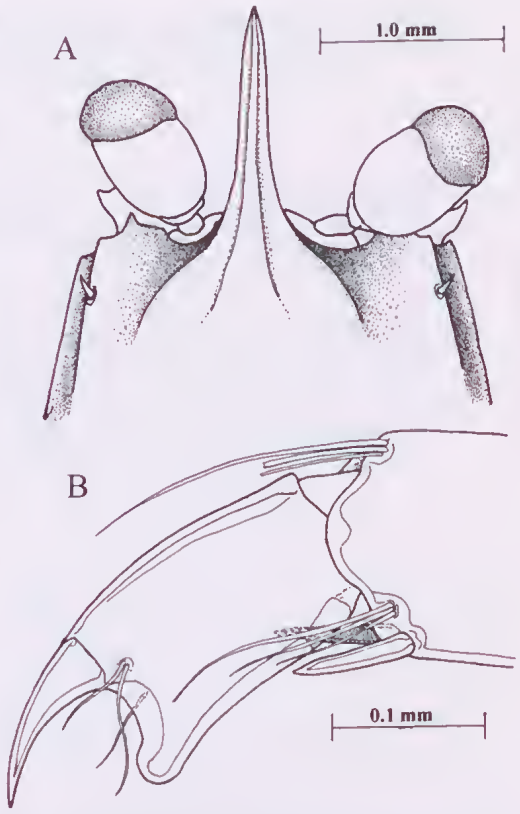

FIG. 1. *Dasella brucei* Berggren, ovigerous ♀, off Mooloolaba. A, anterior carapace and rostrum, dorsal; B, distal propod and dactyl of (?) third pereiopod.

DISTRIBUTION. The type locality at Heron Is., Murdock Point, Mooloolaba and Moreton Bay.

Pseudopontonia minuta (Baker, 1907)
(Fig. 2)

Pontonia minuta Baker, 1907; 189-190, pl. 24, figs 9-12. Hale, 1927: 57, fig. 51. Bruce, 1972: 65-74, figs 1-5. Chace & Bruce, 1993: 62.
Pseudopontonia minuta Bruce, 1992: 1274. Müller, 1993: 128. Li, 2000: 280-281. Davie, 2002: 337-338.

MATERIAL. South Australia: ♀, CL 4.0mm, Port Adelaide, MAFRI Benthic Laboratory Survey, stn 7, 20 December 2002, from pile scrapings, in branchial sac; ♂, CL ca. 4mm, idem, in branchial sac. QMW26553.

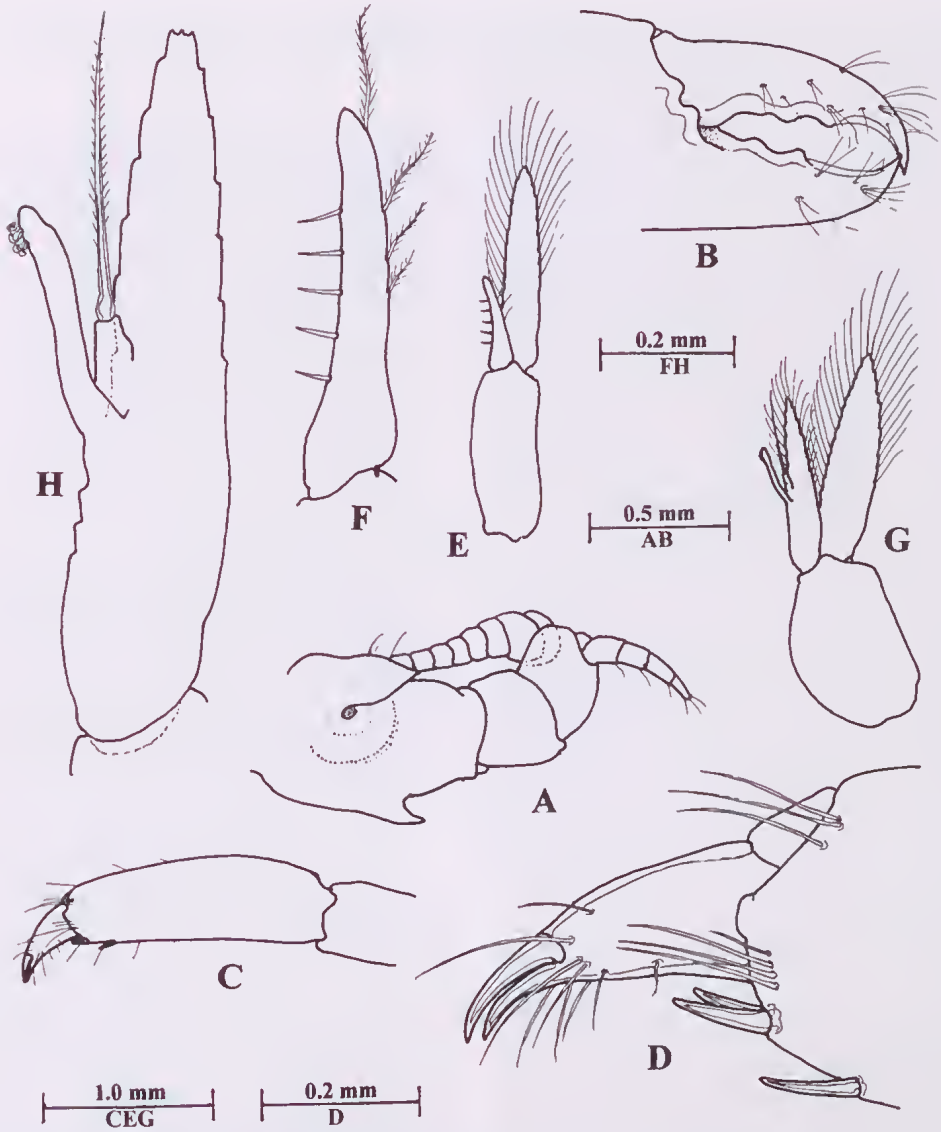

Fig. 2. *Pseudopontonia minuta* (Baker), Port Adelaide, W26553. A, antennule, ventrolateral aspect; B, second pereiopod chela, fingers; C, third pereiopod, propod and dactyl; D, same, distal propod and dactyl; E, first pleopod; F, same, endopod;G, second pleopod; H, same endopod. (A-B, ♀; C-H, ♂).

HOST. *Polycarpa flava* Kott, 1985, (Aseidiacea).

REMARKS. These specimens agree well with earlier descriptions and little further description is necessary. The male has the carapace badly damaged and largely detached, together with the eyes and antennae. The antennular peduncle (Fig. 2A) is robust, the proximal segment stout with a large acute ventromedial tooth. The lower flagellum is short, with only four segments; the upper flagellum is reflexed as in many *Pontonia* species. The fingers of the second pereiopod chelae (Fig. 2B) have strongly curved acute tips, the cutting edges with two low teeth proximally, the distal edge sharp. The third pereiopod propod (Fig. 2C) and dactyl (Fig. 2D) are as previously described. The male first pleopod (Fig. 2E) has the protopodite slender, about 2.4 × longer than wide. The exopod is of subequal length, with

numerous plumose marginal setae. The endopod (Fig. 2F) is about 0.5 of exopod length, slender, tapering, about 4.0 × longer than its basal width, with five short similar simple spines on the central two fourths of the medial margin, three short feebly plumose setae laterally with a further preterminal plumose seta. The second pleopod protopodite (Fig. 2G) is broader, about 1.5 × longer than wide, of similar length to the first, The exopod is similar to the first pleopod. The endopod (Fig. 2H) is about 0.8 of the exopod length, with appendices at about 0.5 of the medial margin length. The appendix interna is long and slender, about 0.3 of the endopod length, with only 4-5 terminal cincinnuli. The appendix masculina is very short and stout, about 0.12 of the endopod length, 2.0 × longer than wide, with a single long feebly plumose terminal spiniform seta, 3.5 × longer than the corpus, reaching to beyond the tip of the endopod.

Pseudopontonia minuta is remarkable amongst pontoniine shrimps, as it is the only species known with abbreviated larval development (Bruce, 1972). All previous specimens have been females. The isolated male and female within the ascidian branchial sac is also surprising as pontoniine associates of ascidians, and other hosts, are usually found as heterosexual pairs. In the case of *Paranchistus armatus* (H. Milne Edwards, 1837) it has been suggested that the high rate of host infestation with heterosexual pairs of shrimps is related to an ample source of larvae (Bruce, 2000). The reverse might apply to the populations of *Pseudopontonia minuta*.

The establishment of the identity of the host for this species removes one obscurity but raises another. A possible association with nereid worms, possibly *Eunice aphrodite*, was suggested by Bruce (1983b). This was based on a colour slide which showed a pair of small red pontoniine shrimps on this host, from Long Reef, Sydney, New South Wales. The identity of these shrimps has not yet been established and would be of special interest as no pontoniine shrimps are presently known to associate with any annelids.

DISTRIBUTION. The type locality 'South Australia', Port Adelaide, South Australia, and Meroo Point and Long Reef, New South Wales.

ACKNOWLEDGEMENTS

I am most grateful to Dr P. Mather for the opportunity to report on these specimens and for information on the hosts. The preparation of this study was facilitated by the support of the Australian Biological Resources Study.

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PERICLIMENES SPECIES (CRUSTACEA: DECAPODA: PONTONIINAE) FROM FAR NORTH QUEENSLAND

A.J. BRUCE

Bruce, A.J. 2003 06 30: *Periclimenes* species (Crustacea: Decapoda: Pontoniinae) from Far North Queensland. *Memoirs of the Queensland Museum* 49(1): 115-122. Brisbane. ISSN 0079-8835.

Recent collections from inshore waters of Cape York have provided specimens of four shrimp species of the genus *Periclimenes* Costa, 1844, from a single locality, Cape Flattery. One is a well known species that has been rarely reported from Australia, two are described as new species and the fourth, damaged, cannot be referred to any described species. ❐ *Decapoda, Caridea, Pontoniinae, Periclimenes, P. adularans, P. paulsoni, new species, Cape York, Queensland.*

A.J. Bruce, Queensland Museum, PO Box 3300, South Brisbane 4101, Australia (e-mail abruce@broad.net.au); 2 July 2002.

Recent surveys of inshore waters of northern Queensland for the Introduced Marine Pests Baseline Survey Projects, by the Marine Biology and Aquaculture Department of James Cook University, suggest that much still remains to be learned about the caridean fauna of this biotope, which has attracted much less scientific attention than the nearby Great Barrier Reef. Of the four species of the pontoniine *Periclimenes* Costa, 1844, only one can be placed in a described taxon, which suggests that more extensive or more detailed sampling might well produce a further substantial increase in the caridean diversity known from this region.

Two of the species are described as new species and a third, represented by a single damaged specimen, probably also represents a further as yet undescribed species. The fourth species collected, *Periclimenes grandis*, is a well known and widely distributed Indo-West Pacific species, but one that has been only infrequently recorded from Australian waters.

In the descriptions, CL refers to the postorbital carapace length; QMW to the Queensland Museum specimen catalogue numbers. Restricted synonymies only are provided. Full synonymies are to be found in Li (2000).

SYSTEMATICS

Subphylum CRUSTACEA
Order DECAPODA Latreille, 1803
Family PALAEMONIDAE Rafinesque, 1815
Sub-family PONTONIINAE Kingsley, 1878

Periclimenes grandis (Stimpson, 1860) (Fig. 1)

Anchistia grandis Stimpson, 1860: 39.

Periclimenes grandis Borradaile, 1898: 382.

Periclimenes (Ancylocaris) grandis Kemp, 1922: 210-214, figs 58-59, pl. 7, fig 10.

Periclimenes grandis Li, 2000: 186-187, fig. 235 (full synonymy).

MATERIAL. 1 ovig. ♀, # Sh 369, Cape Flattery, inner wharf pile, P3, scrapings, 7m, August 2001; 1 ♀, # Sh 370, Cape Flattery, inner wharf pile, P6, 3m, 27 October 2001.

DISTRIBUTION. *Australia*. Queensland: Magnetic Island (Bruce, 1977); John Brewer Reef (Bruce, 1987a); Abbot Point (Hoedt, et al., 2000) Northern Territory: Darwin (Bruce, 1987c); East Point, Darwin (Bruce, 1988a); Cobourg Peninsula (Bruce & Coombes, 1995); Darwin Harbour: Bullocky Point, Cameron Beach, Channel Island, Nightcliffe, Dudley Point, Lee Point, Shell Island, Weed Reef (Bruce & Coombes, 1997). Western Australia: Hibernia Reef (Bruce, 1992).

General. Type locality: Oshima, Japan. Also known from Egypt, Israel, Jibuti, Yemen, Kenya, Zanzibar, Tanganyika, Moçambique, Comoro Islands, Madagascar, Seychelle Islands, Sri Lanka, Burma, Malaya, Singapore, Indonesia, Vietnam, China, Japan, Papua New Guinea, Western Australia, Northern Territory, Queensland, Japan, Caroline Islands, Marshall Islands, Fijian Islands, Tuvalu and Tuamotu Islands.

REMARKS. The present specimens (CLs 4.7, 4.0mm) present no special features. The rostral dentitions are:1 + 6/4, 1 + 5/4. The third ambulatory propod is 11 × longer than wide, with a pair of strong distoventral and 4 ventral spines. The dactyl is 0.28 of the propod length, about 4 × longer than its basal width, rather stouter than as reported by Kemp (1922), who

notes 6-6.5 × longer. This free-living micropredator is probably much commoner in warmer waters than the relatively sparse Australian records suggest. It is surprising that no specimens were found on Heron Island (Bruce, 1981) during collections from 1975 to 1981. Specimens however have been collected from Heron Island (coll. A.H. Banner, 1968). Other specimens have been seen from Bundegi Reef, Exmouth Gulf and North West Cape, Western Australia (coll. N.L. Bruce, 1980).

Periclimenes adularans sp. nov.
(Fig. 2)

MATERIAL. Holotype: 1 ovig. ♀, # Sh 311, Cape Flattery Service Jetty, 27 April 2001, beam trawl, 2m, QM W26554. Paratypes: 1 ♂, # Sh 317, Cape Flattery Service Jetty, 27 April 2001, beam trawl, 2m, coll. QM W26555; 1 ovig. ♀, Sh 371, Cape Flattery, Service Jetty, beam trawl, 15m, 27 October 2001, QM 26556.

ETYMOLOGY. Latin *adulari*, to flatter, after the locality of capture.

DIAGNOSIS. Small slender shrimp of the *holthuisi* species group. Rostrum strongly arched (Fig. 2A), ventrally sinuous, distally concave, reaching to near distal margin of intermediate segment of antennular peduncle, with 13 small acute teeth dorsally in female, 11 in male (Fig. 2B), with single small subterminal tooth ventrally. Carapace with epigastric tooth in female, absent in male; inferior orbital angle (Fig. 2C) strongly produced, acute, with reflected inner flange; hepatic spine slender, slightly anterior to the level of the epigastric tooth in the female; third abdominal tergite slightly posteriorly produced, not carinate; first and second pereiopods normal, similar, slightly unequal, second pereiopod (Fig. 2D) chela (female) (Fig. 2E) 0.9 of CL, with fingers subequal to palm length, dactylus unarmed, fixed finger with 2 minute acute teeth proximally, carpus 0.6 of chela length, subequal to merus: ischium 1.2 × merus length; third ambulatory pereiopod (Fig. 2F) with dactyl (Fig. 2G) slender, 7.7 × longer than basal width, 0.28 of propod length, with small slender accessory tooth at 0.8 of length, closely adpressed, unguis not clearly demarcated: propod about 19 × longer than width, uniform. Compared with the other species of this group, *P. adularans* has a smaller more slender accessory tooth that is closely adpressed to the unguis. The dactylus is distinctly longer and more slender than in the other species of this group, in which the accessory tooth is also stouter and more projecting, about

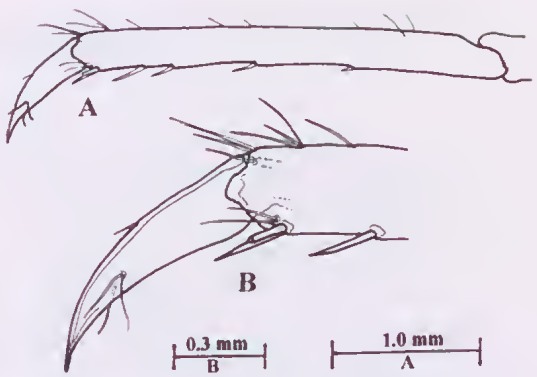

FIG. 1. *Periclimenes grandis* (Stimpson) ovigerous ♀. A, third pereiopod, propod and dactyl. B, same, dactyl.

4× longer than the basal width, and 0.2 of the propod length (Bruce, 1990).

MEASUREMENTS (mm). Holotype, CL 3.7; paratypes: (Sh 317), CL 2.7, (Sh 371), CL 3.4 mm; length of ova 0.5.

SYSTEMATIC POSITION. Closely related to *Periclimenes tosaensis* Kubo, 1951. *Periclimenes adularans* may be easily distinguished from *P. tosaensis* by the accessory tooth on the ambulatory dactylus as this is absent in *P. tosaensis*, the only species of the *holthuisi*-group in which it is lacking. This dactylus is otherwise very similar in these two species, about 7 × longer than the basal width, about 0.28 of the propod length. Compared with the other species of this group, *P. adularans* has a smaller more slender accessory tooth that is closely adpressed to the unguis. The dactylus is distinctly longer and more slender than in the other species of this group, in which the accessory tooth is also stouter and more projecting, about 4 × longer than the basal width, and 0.2 of the propod length (Bruce, 1990).

COLOURATION AND HOST. Not recorded. Trawl catches did not indicate any potential hosts.

HABITAT. Silty mud substrate.

REMARKS. The holotype female has a single second pereiopod. The male lacks its right eye, one first pereiopod, both second pereiopods and fourth and fifth pereiopods. The epigastric tooth also may have been lost artificially. The ovigerous female paratype lacks the distal half of the rostrum, and pereiopods 3-5 on the right side.

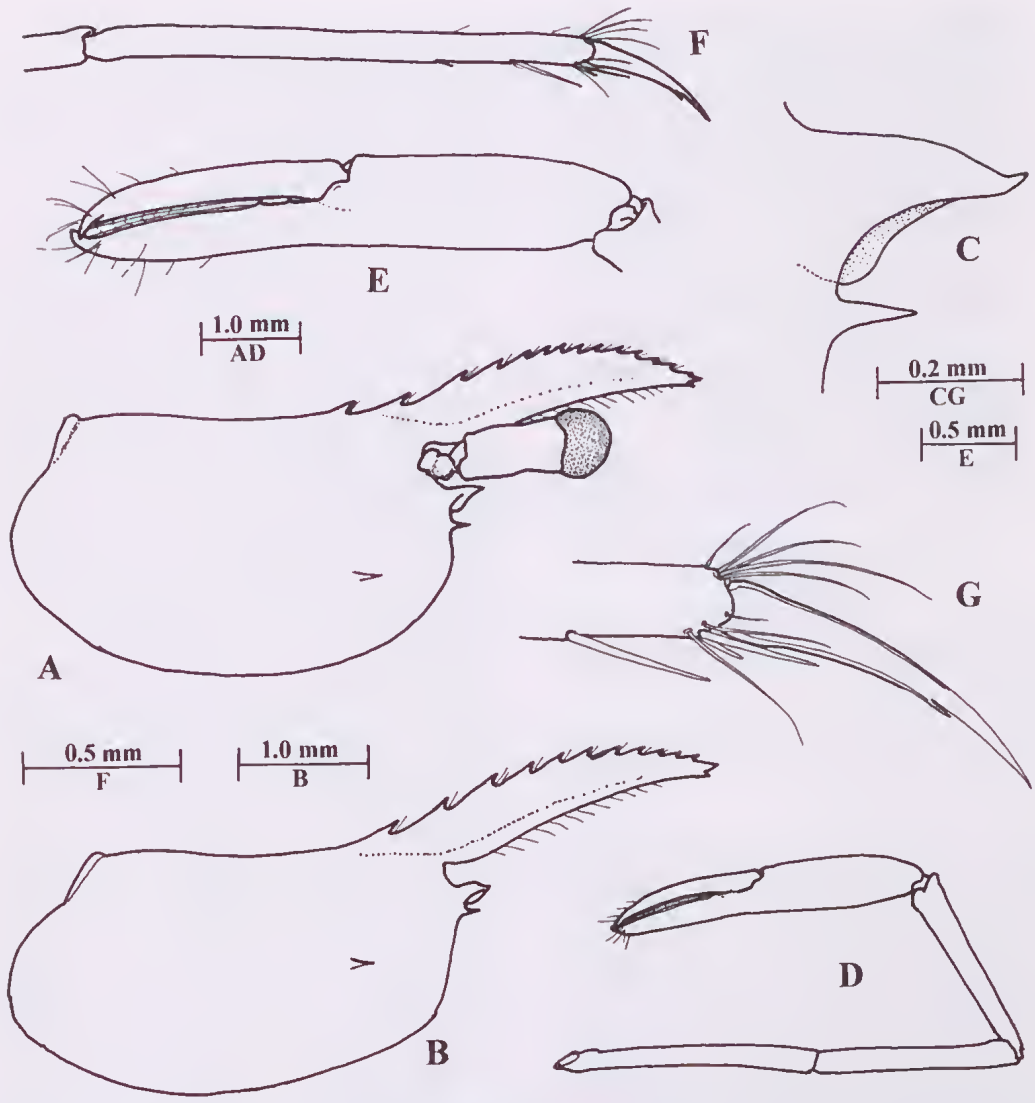

FIG. 2. *Periclimenes adularans* sp. nov. A, carapace and rostrum, ♀; B, same, ♂; C, inferior orbital angle; D, second pereiopod; E, same, chela; F, third pereiopod, propod and dactyl; G, same, distal propod and dactyl. (A,D & E, holotype; B,C,F & G, paratype).

A key to the then 6 species of the *Periclimenes holthuisi* group was provided by Bruce (1990). Since then two further species have been described: *P. tenuirostris* Bruce, 1991, and *P. kobayashii* Okuno & Nomura, 2002. An updated key follows:

1. Ambulatory dactyls simple; R 1 + 7-10/2 . . . . . *P. tosaensis* Kubo

   Ambulatory dactyls biunguiculate 2

2. Carapace with 2-3 postorbital teeth; R 2-3 + 6-7/2-3 . . . . . *P. aesopius* (Bate)

   Carapace with 0-1 postorbital teeth. 3

3. Carpus of second pereiopods distinctly longer than chela; without epigastric tooth; R 5-6/0-2 . . . . . *P. longicarpus* Bruce & Svoboda

   Carpus of second pereiopods shorter than chela 4

4. Fingers of second pereiopod chela with series (5-7) of small acute recurved teeth; propods of ambulatory pereiopods with short distoventral spines; R 1 + 5-7/0-2 . . . . . *P. venustus* Bruce

   Fingers of second pereiopod chelae without series of small acute recurved teeth; propods of ambulatory pereiopods with long distoventral spines 5

5. Second pereiopods with chelae bowed, carpus about 0.6 of palm length; R 1 + 7-8/1-2 . . . *P. magnificus* Bruce

   Second pereiopods with chelae not bowed, carpus subequal to palm length or longer 6

6. Third abdominal tergite without posterior median carina . 7

   Third abdominal tergite with posterior median carina . 8

7. Third ambulatory dactyl 7 or more × longer than basal width, about 0.28 of propod length, with very slender adpressed accessory tooth: R 0-1 + 11-13/1. . . . . *P. adularans* sp. nov.

   Third ambulatory dactyl about 4 × longer than basal width, about 0.2 of propod length, with well developed projecting accessory tooth; R 1 (-2) + 8-11/2-4 . . . . . *P. holthuisi* Bruce

8. Rostrum feebly arched, almost straight, directed upwards, exceeding antennular peduncle; first pereiopod with dactylus longer than palm; R 1 + 6-7/2-3 . . . . *P. tenuirostris* Bruce . . . . . .

   Rostrum distinctly arched not exceeding antennular peduncle; first pereiopod dactylus shorter than palm; R 1 + 6-8/1-3 . . . . . *P. kobayashii* Okuno & Nomura

Periclimenes paulsoni sp. nov.
(Fig. 3A-P)

MATERIAL. 1♂ holotype, Sh 383, Cape Flattery, inner wharf pile, scrapings, 7m, August 2001, coll.# FAK, QM W26557.

ETYMOLOGY. Named in honour of Otto Mikhailovich Paul'son, (1837-86), author of *Studies on the Crustacea of the Red Sea* (1875).

DIAGNOSIS. Small sized slender shrimp of the *grandis* species group. Rostrum (Fig. 3B) slender, about 0.8 of CL, well exceeding antennular peduncle, horizontal, slightly up-curved, with 5 small acute teeth dorsally, 3 ventral teeth, tip acute, simple. Carapace (Fig. 3A) with epigastric tooth, robust marginal antennal spine, inferior orbital angle (Fig. 3C) obsolete; hepatic spine slender, slightly anterior in level to the epigastric tooth; scaphocerite (Fig. 3E) slender, with distal tooth far exceeding lamella; cornea hemispherical (Fig. 3F), diameter about 0.33 of CL; fourth thoracic sternite with slender median process; third abdominal tergite not posteriorly produced; first pereiopods (Fig. 3G,H) normal, exceeding scaphocerite by length of chela, carpus subequal to chela; second pereiopod (Fig. 3I) chela 1.2 of CL, with fingers (Fig. 3J) about 0.4 of palm length, unarmed, acute hooked tips, cutting edges entire, carpus 1.25 of chela length, subequal to merus and ischium length; third ambulatory pereiopod (Fig. 3K) with dactyl (Fig. 3L) robust, simple, curved, 5.7 × longer than basal width, 0.3 of propod length, unguis not clearly demarcated; propod about 10.5 × longer than width, subuniform, with 2 slender distoventral spines, 4 smaller solitary ventral spines; telson and uropods normal.

MEASUREMENTS (mm). Holotype, CL 1.35, carapace and rostrum 3.2; second pereiopod chela 1.9; third pereiopod propod 1.6.

SYSTEMATIC POSITION. *Periclimenes paulsoni* is closely related to *P. anacanthus* Bruce, 1988b and *P. nilandensis* Borradaile, 1915. It may also be closely related to *P. edwardsii* (Paulson, 1875) with which species the specimen was initially identified. *Periclimenes edwardsii* and *P. nilandensis* were not included in the *grandis* species group by Kemp (1922) as they lacked distoventral meral spines on the second pereiopods. Bruce (1987a) revised the species of this group and included all species with a conspicuous finger-like median process on the fourth thoracic sternite, a feature present in *P. paulsoni*, *P. anacanthus* and *P. nilandensis*. It is not known if it is present in *P. edwardsii*, but this seems likely from the close resemblances between the three species.

Periclimenes paulsoni may be distinguished from *P. anacanthus* by the shorter more slender rostrum, about 1.2 of CL, as opposed to 1.6 in male of *P. anacanthus*, lesser rostral dentition, 1 + 5/3, as opposed to 1 + 6-9/2-3; the obsolete inferior orbital angle, well developed, acute in *P. anacanthus*; shorter stouter, 5 segmented fused ramus of upper antennular flagellum, as opposed to long slender 11 segmented ramus; corneal diameter about 0.3 of CL, as opposed to 0.6; first pereiopod carpus subequal to chela; second pereiopod with carpus slightly longer than palm, subequal to meral length, comparatively short and stout, as opposed to longer and more slender in *P. anacanthus*; third pereiopod dactyl about 5.7 × longer than basal width, as opposed to 6.5 ×, propod about 10.5 × longer than width, as opposed to 14.5 × in *P. anacanthus*.

The pleopods (Fig. 3M,O) of *P. paulsoni* are unusual and differ markedly from *P. anacanthus*. They are similar on left and right sides. The first pleopod endopod (Fig. 3N) is simple, tapering distally, about 4 × longer than the basal width, with 3 feeble setae medially. In *P. anacanthus* it is about 7 × longer than the basal width, much expanded centrally, with numerous spines on the concave proximo-medial margin, with numerous fine marginal setae over the rest of the expanded portion. The endopod of the male second pleopod (Fig. 3P) is much reduced in *P. paulsoni*, about 0.6 of the exopod length, with a small appendix interna at 0.75 of the length. The appendix

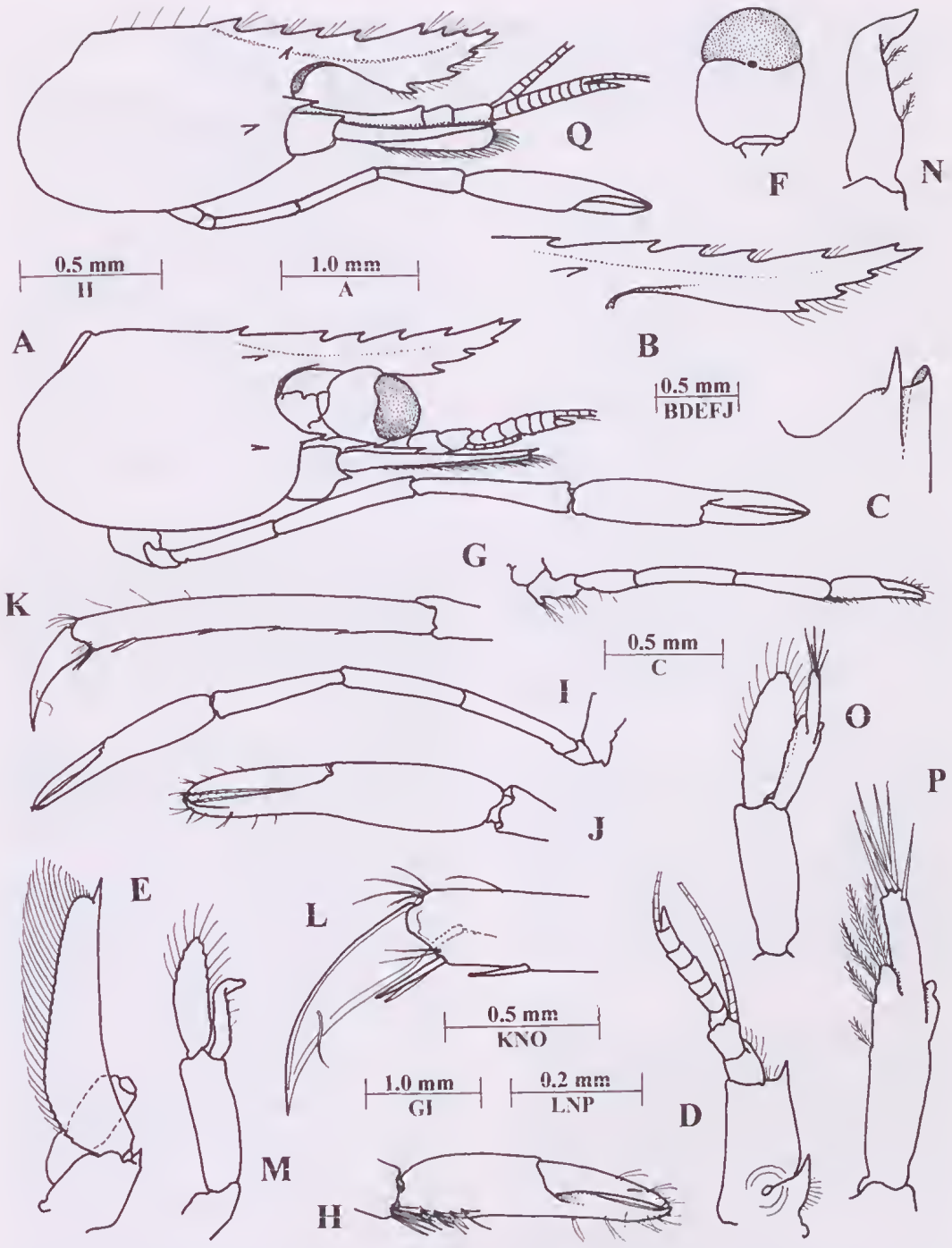

FIG. 3. A-P, *Periclimenes paulsoni* sp. nov. holotype ♂. A, carapace and appendages; B, rostrum; C, inferior orbital angle, dorsal aspect; D, antennule; E, antenna; F, eye, dorsal; G, first pereiopod; H, same, chela; I, second pereiopod; J, same, chela; K, third pereiopod, propod and dactyl; L, same, distal propod and dactyl; M, first pleopod; N, same, endopod; O, second pleopod; P, same, endopod. Q, *Periclimenes edwardsii* (Paulson), redrawn from Paulson (1875).

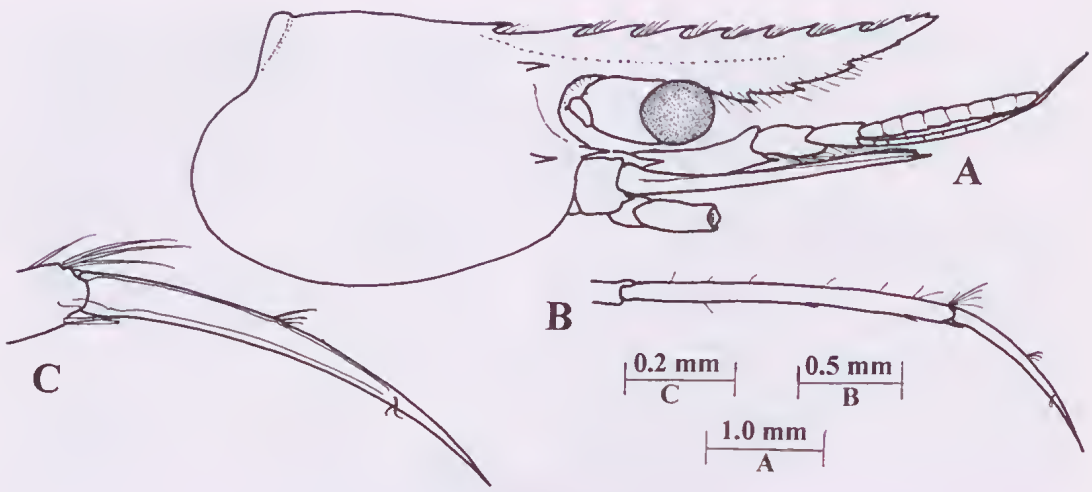

FIG. 4. *Periclimenes* sp., aff. *anacanthus* Bruce. A, carapace and appendages; B, third pereiopod, propod and dactyl; C, same, distal propod and dactyl.

masculina is very well-developed, about 0.6 of the endopod length, far exceeding the end of the endopod, with 5 long simple terminal spines and 1 slightly preterminal spine. In *P. anacanthus* the appendix masculina is much shorter than the endopod, which is well-developed, about 0.6 of its length, and has 6 terminal spines, with 4 spines along the ventral surface.

Periclimenes paulsoni also resembles *P. nilandensis* Borradaile, 1915. This species has a distally broad scaphocerite, not greatly over reached by the terminal tooth, a well developed inferior orbital angle not found in *P. paulsoni*, the first pereiopod carpus is markedly longer than the chela, the second pereiopod carpus is markedly shorter than the merus and the rostral dentition of 1 + 7-8/3-4, with the first tooth situated on the carapace.

The present specimen of *P. paulsoni* was initially thought to be referrable to *P. edwardsii* (Paulson, 1875), a little known species that has rarely been reported since its original description. The loss of all Paulson's material has handicapped further description of this species. *P. edwardsii* (Fig. 3Q) has a deeper rostrum than *P. paulsoni*, with a rostral dentition of 1 + 7/3, with a bifid tip, an obsolete inferior orbital angle very similar to *P. paulsoni*, and a relatively broad scaphocerite with the lamella exceeding the tip of the distolateral tooth. Ledoyer (1968) reported on a number of specimens as *P.* cf. *edwardsi* from Tuléar, Madagascar, on the basis of the assessment by Kemp (1922), and illustrated the major features. The figure shows a rostral dentition of 1 + 6/2 and a feebly produced inferior orbital angle. His material differs from Paulson's particularly in the second pereiopod where the slender carpus, 7 × longer than the distal width, is subequal to the palm length, about 4 × longer than wide and 0.6 of the palm length in *P. edwardsii* s.str.

The key to the species of the expanded '*Periclimenes grandis* species group' given in Bruce (1987b) was augmented in Bruce (1988b). A further augmentation is provided below, to include *P. paulsoni* and *P. edwardsii*, which was not included in the 1987a key.

16. Supraorbital spines present 16a
Supraorbital spines absent 17

16a Second pereiopod carpus much longer than palm; R. 1 + 6-9/2-3 . . . . . *P. anacanthus* Bruce
Second pereiopod carpus not longer than palm . . . 16b

16b Inferior orbital angle obsolete; R. 1 + 5/3 . . . . . *P. paulsoni* sp. nov.
Inferior orbital angle distinct. 16c

16c Rostral lamina slender, second pereiopod carpus distinctly shorter than merus; R. 1 + 7-8/3-4 . . . . . *P. nilandensis* Borradaile
Rostral lamina deep, second pereiopod carpus subequal to merus; R. 1 + 7/3 . . . . . *P. edwardsii* (Paulson)

Couplet 13 of the original key also contained some unfortunate errors and should read:

13. Epigastric and first three dorsal teeth grouped and enlarged; ambulatory propods with distal ventral spine only; R. 1 - 6-7/3-4 . . . . . *P. kororensis* Bruce
Dorsal teeth similar and evenly distributed; ambulatory propods ventrally spinulate; R. 1 + 6/5-6 . . . . . *P. platycheles* Holthuis

Periclimenes sp. aff. anacanthus Bruce, 1988 (Fig. 4)

MATERIAL. 1♀, Sh 305, Cape Flattery, Service Jetty, beam trawl, 5m, August 2001, QM W26558.

REMARKS. The single specimen, CL 2.4mm, with a well-developed median process on the fourth thoracic sternite, unfortunately lacks both second pereiopods. The rostrum (Fig. 4A), about 1.25 × the CL, far exceeds the antennular peduncle and has a dentition of 1 + 9/4, the distal ventral tooth being minute. The inferior orbital angle is not acutely produced, almost obsolete. The first pereiopod has the carpus about 1.35 × the chela length. The propod of the third pereiopod (Fig. 4B) is about 0.78 of the CL, 18.6 × longer than wide, with a pair of small distoventral spines and two minute ventral spines only. The dactyl (Fig. 4C) is about 0.57 of the propod length, 8.5 × longer than the proximal depth.

None of the other species of the '*grandis* group' that have supraorbital spines have such slender ambulatory dactyls, except *P. anacanthus*. This species has an acutely produced inferior orbital angle, the first pereiopod carpus about 1.8 × the chela length, the third perciopod propod about 14.5 of the CL, with long distoventral spines and numerous well developed ventral spines, and the dactylus is about 0.4 of the propod length, 6.5 × longer than its proximal depth. *P. anacanthus* is known from Moreton Bay, Queensland and the Cobourg Peninsula, Northern Territory.

The Cape Flattery specimen also shows some similarity to *P. digitalis* Kemp (1922), which has much more slender ambulatory dactyls, about 14 × longer than the proximal depth and 0.45 of the length of the propod, which also lacks ventral spinules. *Periclimenes digitalis* lacks a supraorbital spine, having only a small tubercle in this position. *Periclimenes digitalis* has been reported from the Andaman Islands, Singapore, Hong Kong, China and Indonesia.

This specimen cannot be referred to any of the described species of the '*grandis* species group' and appears to represent a distinct taxon. Without second pereiopods it is not suitable for designation as a holotype specimen and the collection of further complete specimens must be awaited for a full description.

ACKNOWLEDGEMENTS

I am most grateful to Dr Kerry Neil for the opportunity to report on these shrimps. The specimens were collected by Juan Cruz, John Ackerman, Phil Osmond and Damian Thomson. This study was facilitated by support from the Australian Biological Resources Study.

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ADDENDUM

Since the preparation of this article a further species of the *Periclimenes holthuisi* species group has been described from the Ryukyu Islands, Japan by Okuno (2002). This species, *Periclimenes sarasvati* Okuno, is most closely related to *Periclimenes venustus* Bruce (1990) and may be distinguished from that species by the absence of a *bâc ocellaire*, the presence of a bilobed distal maxillary endite, the second pereiopods exceeding the scaphocerite by the proximal part of the palm, with the fingers bearing 2-4 acute recurved teeth and a rostral dentition of 7-9/1-2.

SYSTEMATICS AND NEW TAXA OF THE *VANNIUS* COMPLEX (HEMIPTERA: MIRIDAE: CYLAPINAE) FROM THE AUSTRALIAN REGION

GERASIMOS CASSIS, MICHAEL D. SCHWARTZ AND TIMOTHY MOULDS

Cassis, G., Schwartz, M.D. & Moulds, T. 2003 06 30: Systematics and new taxa of the *Vannius* complex (Hemiptera: Miridae: Cylapinae) from the Australian Region. *Memoirs of the Queensland Museum* **49**(1): 123-151. Brisbane. ISSN 0079-8835.

Erection of the tribe Vanniini and its placement in the subfamily Palaucorinae, as proposed by Gorczyca (1997), is rejected. An informal group, the *Vannius* complex (Cylapinae: Cylapini) is recognised, comprised of *Afrovannius* Gorczyca, *Austrovannius* gen. nov., *Paracylapus* Carvalho, *Vanniopsis* Poppius, *Vannius* Distant, and *Vanniusoides* Carvalho & Lorenzato. *Austrovannius* nov. gen. is described, including three new species, *A. platnicki* sp. nov., *A. scutica* sp. nov., and *A. xepenehense* sp. nov. New species belonging to existing genera within the *Vannius* complex are described, including: *Vanniopsis howense* sp. nov., *Vanniusoides asprokara* sp. nov. and *Vanniusoides melafrons* sp. nov. *Vanniopsis rufescens* Poppius, 1909 is redescribed and the male genitalia are illustrated for the first time. Illustrations of male and female genitalia are given for the new species. A cladistic analysis of the genera of the *Vannius* complex is presented and the systematic position of the complex is discussed. ❐ *Hemiptera, Miridae, Cylapinae, Vannius complex, Australian region.*

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The Cylapinae are a basal group of Miridae (Schuh, 1975) whose systematics and biology are probably the least known in the family. Schuh (1995) and Schuh & Slater (1995) rejected the notion of meaningful monophyletic infrafamilial groups within the Cylapinae, as suggested by previous authors such as Carvalho (1952, 1957: Bothriomirini, Cylapini & Fulviini). Gorczyca (1997, 1998) has attempted to clarify the supragenerie classification, although this author has recently rejected his own inital findings (i.e. *Vannius* complex as a tribe within the Palaucorinae).

Gorczyca (1997) recognised the *Vannius* complex as a monophyletic tribe of mirids because of the spatulate parempodia, a condition unique in basal Miridae. He recognised this complex as containing *Afrovannius* Gorczyca, *Austrovannius* gen. nov., *Paracylapus* Carvalho, *Vanniopsis* Poppius, *Vannius* Distant and *Vanniusoides* Carvalho & Lorenzato.

This work reports on an examination of new material from the Australian region, with new species described from the Australian mainland, Lord Howe Island, Fiji, New Caledonia and Vanuatu. This study also includes a broader overview of the systematics of the *Vannius* complex, with a description of three genera (*Austrovannius*, *Vanniopsis* and *Vanniusoides*) from the Australian region. In addition, the ingroup relationships of the *Vannius* complex are analysed, and their position within the Cylapinae is discussed.

The Cylapinae, as with most mirid subfamilies, are poorly documented for Australia. Cassis & Gross (1995) listed only nine genera and 11 species, yet existing collections indicate that the cylapine fauna of Australia, may be an order of magnitude more species rich. This work is part of a series on the systematics of the Miridae of the Australian region, and the results herein are the first record of the *Vannius* complex from Australia.

This paper is based on a study of existing collections from the tropical parts of the Australian region, including the southwest Pacific. A smaller collection of other specimens from New Caledonia has been examined but not included in this paper. This material represents at least another ten new species of *Austrovannius*, and it is apparent that material examined from each mountain top is an endemic species. This material will be the subject of a second paper, as we await the collection of additional specimens.

MATERIALS AND METHODS

This study was based on about 100 specimens, borrowed from the Bernice P. Bishop Museum

(BPBM), the Queensland Museum (QM), the South Australian Museum (SAMA), and the University of Queensland Insect Collection (UQIC). Dr Roger Kitching (Griffith University) provided one specimen. The holotypes of *Austrovannius platnicki* sp. nov. and *A. xepenehense* sp. nov. are lodged in the Muséum National d'Histoire Naturelle, Paris (MNHP). Material was also collected by us during fieldwork on Lord Howe Island and New Caledonia, and is housed at the Australian Museum (AM). Geographic coordinates for specimens without such information were calculated using GIS techniques, and are given in brackets in the Materials section of the species descriptions.

All measurements are maximum lengths and the range for each species is given in millimeters. Abbreviations for morphometric characters are: BL = body length; HW = head width across eyes; IOD = interocular distance; HL = head length; PL = pronotal length; PW pronotal width at humeral angles; AII = length of second antennal segment; and, LL = labial length.

Scanning electron micrographs were prepared using techniques outlined in Bolte (1996) and Swearingen et al. (1997).

Colour images were captured using a Nikon DX1 digital camera fitted with an Infinity K2 long distance microscope and a CF-3 objective. Illumination was supplied by the Mieroptic ML-1000 fiber optics system with the images relayed directly to Nikon Capture 2 software.

The data were constructed and analysed using Winclada (Nixon, 1999) and NONA (Goloboff, 1999). The characters are unweighted and all multistate characters are unordered. The following three taxa were used as outgroups: *Bothriomiris lugubris* Poppius, *Peritropisca bituberculata* Carvalho and Lorenzato and an undetermined species of *Cylapocerus* Carvalho.

BIOLOGY. The biology of the basal suprageneric groups (Isometopinae, Cylapinae, Psallopinae) of the Miridae are subject to debate because of a lack of empirical evidence (Schuh, 1975, Cassis & Gross, 1995; Wheeler, 2001). Many researchers (e.g. Schuh, 1976; Carvalho & Lorenzato, 1978) have argued that Cylapinae are stenotopic in their habits, being associated with the mycelia and fruiting bodies of higher fungi, in habitats such as fallen logs and under bark. There are some observations that support the notion that cylapines are mycetophagous (Schuh, 1975). Most cylapines (aside from Bothriomirini and most members of the *Vannius* complex) are characterised by an extremely elongate labium, which is suggestive of fungal feeding. Unlike in the Aradidae, which are well documented fungal feeders, the labium of cylapines does not possess coiled stylets, and there have been no reports on the mechanism of cylapine feeding. Wheeler (2001) suggested that some cyalpines, particularly Fulviini, are predaceous.

There is very limited knowledge of the biology of species of the *Vannius* complex. We found a new species of *Vanniopsis* from Lord Howe Island, *V. howense* sp. nov., in lowland rainforest, associated with leaf mould of fallen palm leaves (*Howea fosteriana* Becc.). This microhabitat was characterised by dense matts of fungal mycelia and high moisture content. *V. howense* was found in association with other heteropteran taxa; *Acaraptera* Usinger & Matsuda (Aradidae), and two species of Reduviidae: Emesinae (*Emesopsis* sp. and *Atisne derelictus* Wygodzinsky). Similarly, *Vanniopsis rufescens* Poppius and the new species of *Austrovannius* have been collected amongst leaf litter in rainforests. These data provide indirect support that the *Vannius* complex, like other cylapines are associated with fungi. Other species of *Vanniopsis* are known from vegetation, including sweeping ferns. Chris Reid (pers. comm.) observed that *V. howense* was occasionally collected on ferns. *Vanniopsis crobylos* has also been collected from a low plant (*Elatostema* sp. [Urticaceae]). Together, the above data suggest that *Vanniopsis* species are epigaeic but frequent low vegetation during the day.

Austrovannius species are also primarily ground-dwelling, collected from either sieved litter or by pyrethrum fogging of fallen logs. Nothing is known of the biology of the species of *Vanniusoides* that are described in this work. Gorczyca & Konstantinov (2001) reported that *Vanniusoides clypeatus* Gorczyca & Konstantinov is found in a riparian habitat amongst stones.

There is also limited biological information for species of the *Vannius* complex from the Afrotropical and Neotropical regions. Gorczyca (1996, 1997) and Gorczyca & Konstantinov (2001) reported that *Paracylapus lestoni* is found on fungi, and species of *Vannius* are known from fruit and flowers.

HOMOLOGY AND TERMINOLOGY. A range of external morphological and genitalic characters are used to differentiate genera and species within the *Vannius* complex. Homology and terminology for non-genitalic characters are

consistent with those described in Cassis (1995 and references therein) and Cassis & Moulds (1995). The homology and terminology of the male genitalia follow Kelton (1959) for gross features, and Stonedahl (1988) for specific attributes of the endosoma. The homology of the male genitalia proposed by Kerzhner & Konstantinov (1999) is not employed in this work. We use the term endosoma to refer to the aedeagus distal to the secondary gonopore. The descriptions of the female genitalia are based on Slater (1950) and Davis (1955). Modifications to terminology for the female genitalia by Schwartz & Footitt (1998) are used.

Colouration. The colour of the body, particularly the dorsum is critical in differentiating species in the *Vannius* complex. Aside from *Vanniopsis crobylos* and *V. rufescens*, most taxa are determined by colour patterns of the dorsum, particularly of the pronotum and forewings. These patterns have a generalised form, which are partially characteristic the *Vannius* complex, and are composed of a pallid background, interspersed with species-specific red markings (Fig. 3). We refer to these patterns as disruptive colouration. In addition, there are associated red markings of lateral aspects of the head and the thoracic pleura. The colour patterning of the second antennal segment is valuable in discriminating genera and species, with All either banded (Fig. 3C) or concolorous (Fig. 3A,B).

Texture. The body of most taxa of the *Vannius* complex is smooth, aside from two species of *Vanniopsis* (*V. crobylos* and *V. rufescens*) which have a weakly rugose dorsum.

Vestiture. The vestiture of the *Vannius* complex is not significant taxonomically. In general, the setae are simple, usually bristle-like, and of sparse to moderate distribution (Fig. 3D).

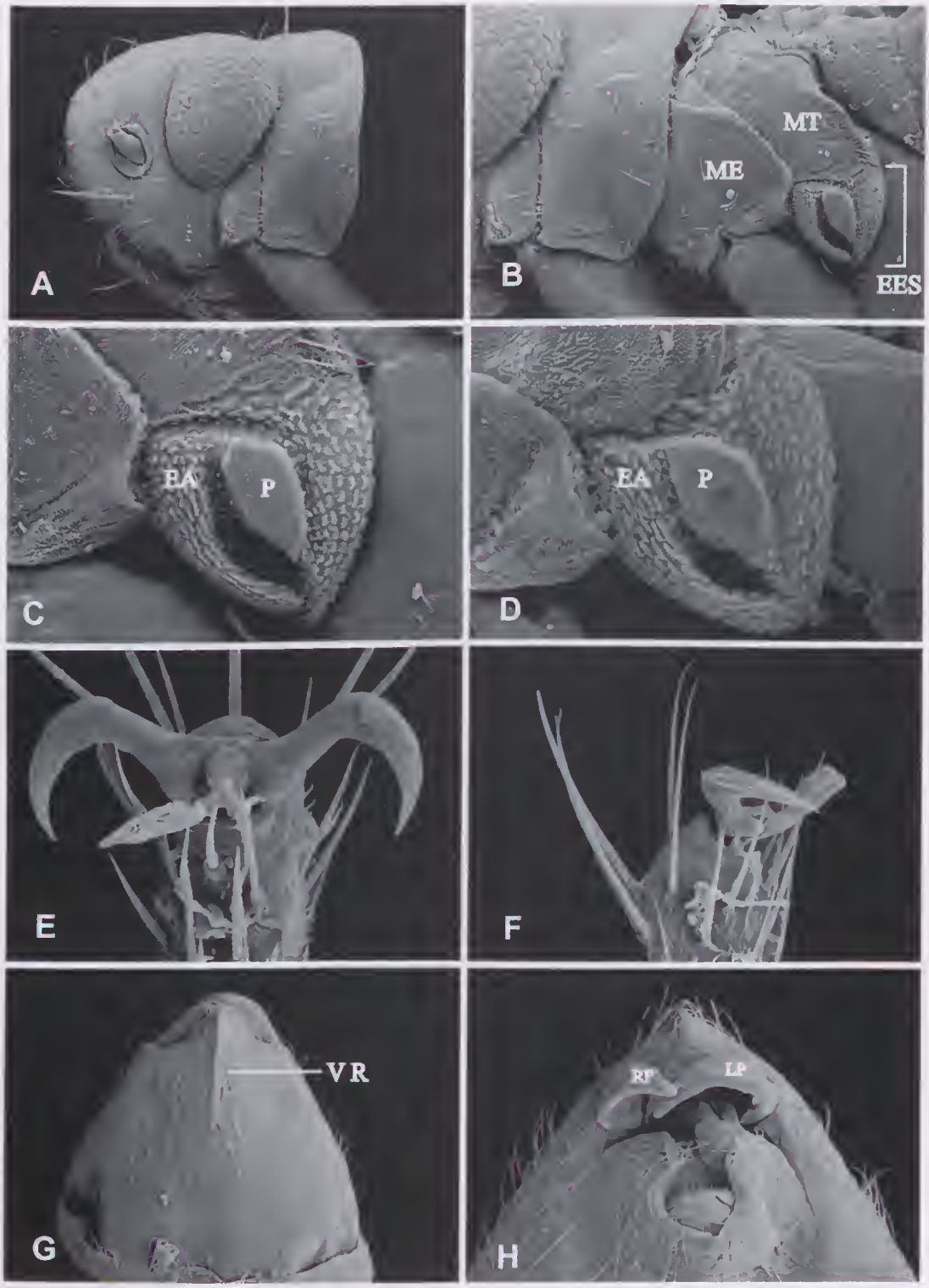
Head. The head is vertical in orientation (Fig. 1A), with the clypeus, and mandibular and maxillary plates cone-like, with the bucculae small and arcuate. The gular is consequently greatly reduced in size. Gorczyca (1997; figs 11-16) illustrated differences of the head between genera. There are some species differences found in *Vanniusoides*, where the clypeus and mandibular plates are apically rounded; cf. *V. clypeatus* (see Gorczyca & Konstantinov, 2001; fig. 4) and other *Vanniusoides* species. The most significant character examined was the presence of the longitudinal suture found on the vertex (and frons partially), which was either absent (*Austrovannius* and *Vanniusoides*) (e.g. Figs 3A, 6) or present (*Vanniopsis*) (Fig. 2A). In most taxa of the *Vannius* complex the antennae are much longer than the body and thread-like (e.g. Figs 3A,B,D, 6, 13). Antennal length is useful in differentiating species of *Vanniopsis*, with *V. crobylos* and *V. rufescens* (Fig. 3C) having relatively short antennae (as long as the body), whereas *V. howense* have the antennae significantly longer than the body (Fig. 13). The length of the first antennal segment is critical in determining *Vanniopsis*, having A1 much longer than the head (Figs 3A-C, 13). In other taxa of the *Vannius* complex, A1 is subequal in length to the head (Figs 3D, 6, 8). The length of the labium is not as significant, with most taxa having the labium reaching between the meso and metacoxae, aside from *Austrovannius*, which has an extremely elongate labium, reaching between abdominal sternum VII and the genital segments.

Pronotum. The flattened broad collar (Figs 3A-C, 2A, 13) is diagnostic for the *Vannius* complex. The collar is almost vestigial in *Austrovannius* (Fig. 1A), however, this is likely correlated to wing reduction. It is noteworthy that *Vanniopsis howense* also has staphylinoid wings (Fig. 13), but possesses a broad flattened collar. Other pronotal characters of significance include the campanulate pronotum (Fig. 3A-C), the undifferentiated disc (without calli) and the bisinuate posterior margin (Fig. 3A-C).

Thoracic Pleura. Thoracic pleura are largely uninformative, aside from the metathoracic spiracle and peritreme of the external efferent system of the metathoracic glands. The metathoracic spiracle is either concealed (Fig.1B) or exposed (Fig. 2C). The peritreme is either medially (Figs 1B-D, 2C) placed on the metepisternum, or adjacent to the anterior margin of the metepisternum, as in the remainder of the Cylapini (Cassis, 1995, fig. 128).

Forewings. Wing polymorphism is diagnostic at the genus and species levels in the *Vannius* complex. Staphylinoidy (*sensu* Schuh & Slater 1995) is diagnostic for *Austrovannius* (Figs 3D, 6, 8), *Vanniopsis howense* (Fig. 13) and *Vanniusoides brevis*. All other taxa of the *Vannius* complex are macropterous.

Legs. Legs are elongate in the *Vannius* complex, and are exaggerated in *Austrovannius* (Figs 6, 8), and some species of *Vanniopsis* (Fig. 13) and *Vanniusoides*. Tarsi are uniformly two-segmented in the *Vannius* complex. The pretarsus has spatulate parempodia (Fig. 1E,F), which is diagnostic and synapomorphic for the *Vannius*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complex. The absence (Fig. 1E) or presence (Fig. 2F) of subapical teeth is diagnostic at the generic level, and in some cases the number of teeth varies (Gorczyca, 1997).

Male Genitalia. The pygophore is diagnostic for certain genera. In most taxa the genital opening of the pygophore is dorsal in orientation (Fig. 1H), or rarely terminal (Fig. 2E). The ventral surface of the pygophore is impressed along the midline in *Austrovannius* (Fig. 1G). The structures of the aedeagus (Figs 5C, 7C, 9C, 12C, 14C, 15C, 18C) are of primary significance in determining genera and species in the *Vannius* complex. The presence of basal sclerites (Figs 5C, 7C, 9C, 12C, 14C, 15C, 18C) and the number and location of lobal sclerites (Figs 7C, 9C) of the endosoma are variable among genera, although their form is consistent within species. The secondary gonopore is either indistinguishable (*Vannius* and *Vanniopsis*) (Figs 12C, 14C, 15C, 18C) or strongly sclerotised and cup-shaped, with the aperture dentate (*Afrovannius*, *Austrovannius*, *Paracylapus*, and *Vanniusoides*) (Figs 5C, 7C, 9C).

Female Genitalia. The sclerotised rings (Figs 10A,C, 16A,C,E 19A,C) and associated ventral and dorsal labiate plates, as well as the inter-ramal sclerite and associated inter-ramal lobes (Figs 10B,D, 16B,D,F, 19B,D) are useful for distinguishing both genera and species of the *Vannius* complex. In *Austrovannius* the sclerotised rings (Figs 10A,C) and posterior wall (Figs 10B,D) and their associated components have a complexity of structure not found in either *Vanniopsis* and *Vanniusoides*. The species of the latter two genera have thin, simple, flattened rings (Figs 16A,C,E, 19A,C) placed between separate ventral labiate plates and wide, sometimes scroll-like, dorsal labiate plates. In contrast, species of *Austrovannius* have large, ornate, asymmetrical rings (Fig. 10C) between a convoluted, entire ventral plate and strongly sclerotised, but narrower, dorsal plates. Similarly the posterior wall of *Austravannius* species are complete (Fig. 10B,D), spanning the base of the first valvifers, with spinose and bulbous inter-ramal lobes. Species of *Vanniopsis* and *Vanniusoides* (Figs 16B,D,F 19B,D), in comparison, have slight, bilaterally separated inter-ramal sclerite with lobes.

VANNIUS COMPLEX

DIAGNOSIS. The *Vannius* complex is recognised by the following combination of characters: head vertical (Fig. 1A); elongate thread-like antennae (Fig. 3D); pronotal collar broad and flat (Fig. 13); elongate metafemora (Fig. 3B); tarsi two-segmented (Figs 6, 8, 13); spatulate parempodia (Figs 1F, 2F); pretarsus lacking pulvilli or pseudopulvilli (Fig. 1E); and, endosoma with basal sclerites (strap-like and/or digitiform) (Fig. 5).

DESCRIPTION. *Colouration.* Body either stramineous to mostly red, if pale often with disruptive colouration (Fig. 3), with red markings on head, pronotum, thoracic pleura and forewings. Antennae often concolorous (Fig. 3B), stramineous to brown, sometimes with reddish highlighting, less commonly with AII banded (Fig. 3B). Legs often pale, sometimes femora with red banding (Fig. 3B). Abdomen either stramineous to red, often concolorous, less commonly dark, sometimes with paler regions ventrally.

Texture. Body smooth; impunctate; dorsum sometimes weakly rugose.

Vestiture. Body with sparse to moderate distribution of decumbent to semi-erect, pale to dark, soft to stiff (bristle-like) setae (Fig. 3D)

Structure. Macropterous (Fig. 3A-C) or staphylinoid (Figs 3D, 6, 8, 13); elongate to elongate-ovoid. Head subtriangular (Fig. 2A) to oval; transverse (Fig. 3A); vertical (Figs 1A, 2B); clypeus not visible from above, posteroventrally directed, usually flat, sometimes weakly swollen, sometimes with postclypeal processes; vertex flat to weakly convex (Fig. 2A), sometimes with weak depressions medially, often with shallow longitudinal sulcus (Fig. 2A); bucculae short, arcuate; mandibular plate greatly enlarged, triangular (Figs 1A, 2B); eyes enlarged, contiguous with anterior margin of pronotum (Figs 1A, 2A,B), not significantly extending beyond plane of head (Fig. 1A); ocelli absent (Fig. 2A). Antennae elongate, thread-like, at least as long as the body (Fig. 3D); AI weakly swollen,

FIG. 1. Scanning electron micrographs. A-C, E-G *Austrovannius xepenehense*, D and H *Austrovannius scutica*. A, head, lateral view; B, thoracic pleura, metathoracic glands, lateral view; C, peritreme and evaporative area; D, peritreme and evaporative area; E, strongly recurved tarsi, ventral view; F, tarsi, lateral view; G, pygophore, ventral view; H, pygophore dorsal view. EA = evaporative area, LP = left paramere, P = peritreme, RP = right paramere, VR = ventral ridge.

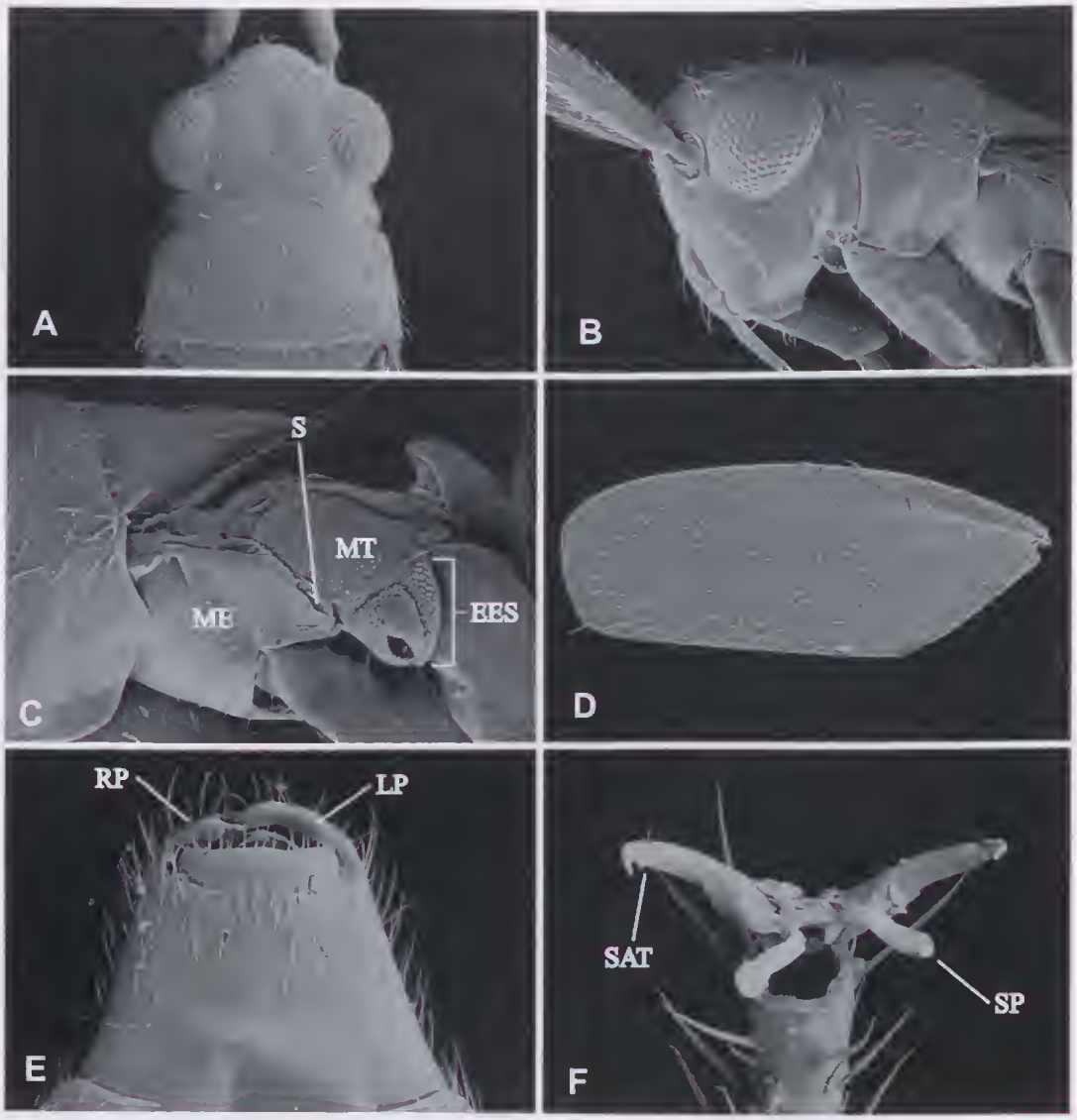

FIG. 2. Scanning electron micrographs. *Vanniopsis howense*. A, head and pronotum, dorsal view; B, head and pronotum, lateral view; C, thoracic pleura, lateral view; D, forewing, dorsal view; E, pygophore, dorsal view; F, pretarsus, ventral view. EES = external efferent system of metathoracic glands, LP = left paramere, ME = mesepimeron, MT = metepisternum, RP = right paramere, S = metathoracic spiracle, SAT = subapical tooth, SP = spatulate parempodia.

either subequal in length to head length (Fig. 3D) or significantly longer (Figs 3A-C, 13), either cylindrical or bilaterally compressed and outwardly arcuate (Figs 3B, 13); AII cylindrical, thin, elongate, longer than posterior width of pronotum (Figs 3, 6, 8, 13); AIII-IV extremely thin (Fig. 3D), cylindrical, elongate. Labrum subtriangular, shorter than first labial segment. Labium usually extending between meso and metacoxae, rarely elongate, reaching genital segments; LI longer than bucculae; LII often short. Pronotum transverse; often campanulate (Fig. 3A-C) with broad flattened collar, or in wing shortened species collar usually vestigial (Figs 6, 8), with pronotum ring-like and short; callosite region absent; posterior margin of

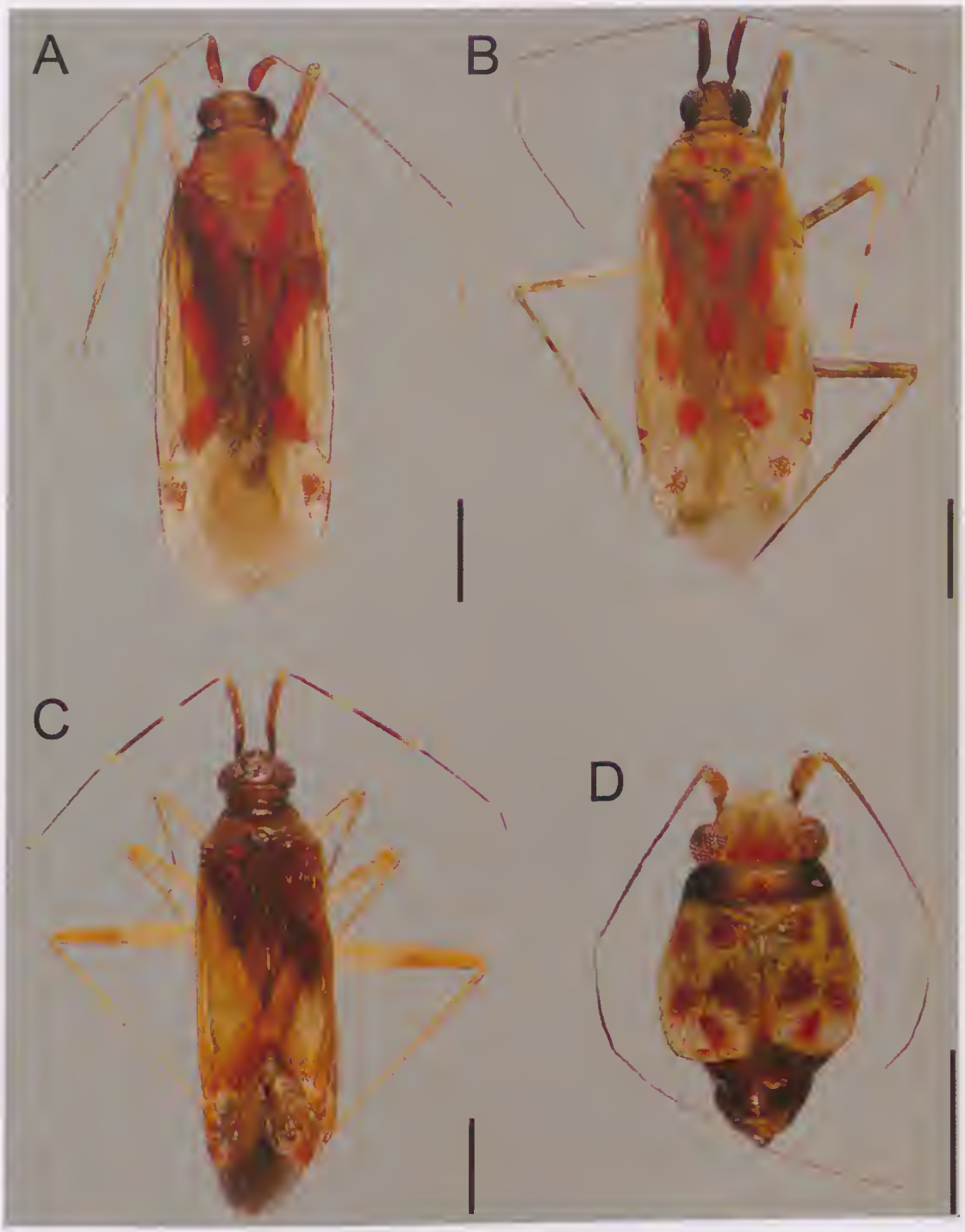

FIG. 3. Habitus photographs. A, *Vanniusoides asprokara*; B, *Vanniusoides melafrons*; C, *Vanniopsis rufescens*; D, *Austrovannius xepenehense*. Scale bar = 1.0mm.

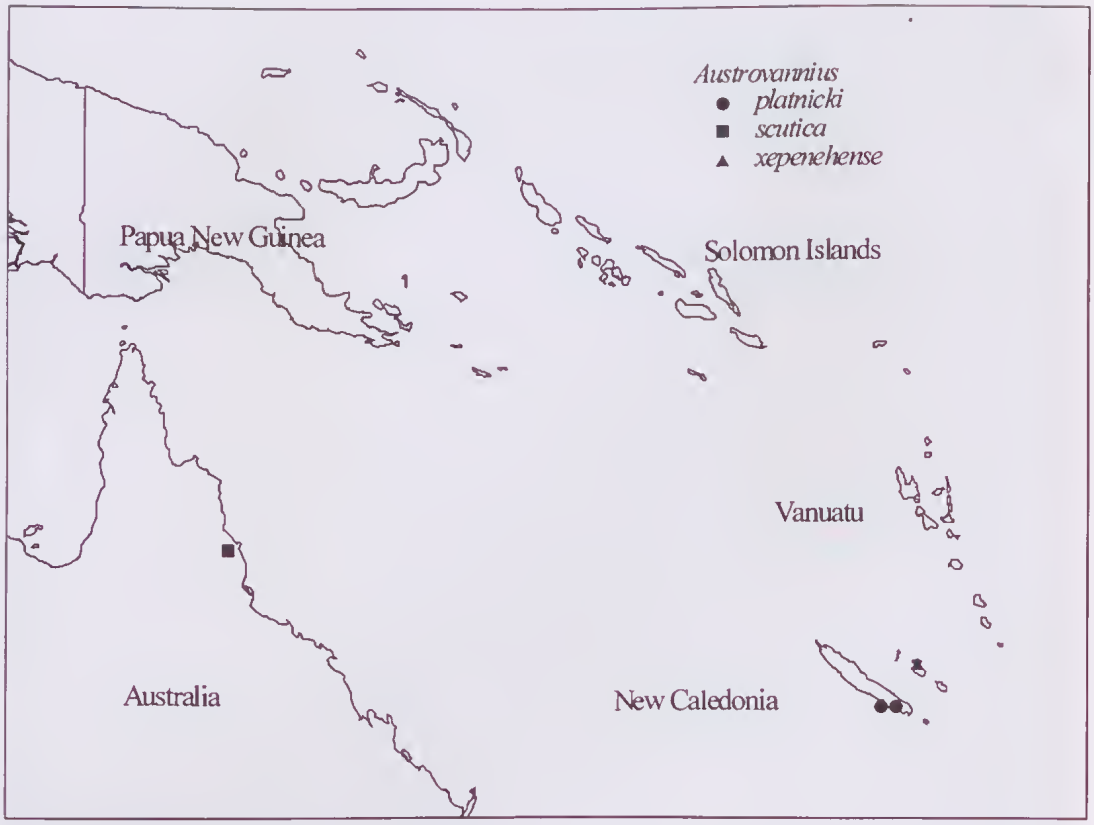

FIG. 4. Distribution map of *Austrovannius* species.

pronotum either bisinuate (Fig. 3A-C) or rectilinear (Figs 6, 8). Hemelytra: maeropterous species with wings weakly to strongly deflexed at cuneal fracture; cuneal fracture small to moderately large; cuneus elongate and usually narrow; two membrane cells (Fig. 3A,B). Procpisternum anteriorly directed (Figs 1A, 2B); proepimeron flat or medially depressed. Mesepimeron broadly fused with mesosternum (Fig. 2C); metathoracic spiracle exposed (Fig. 2C) or concealed (Fig. 1B); evaporative bodies on ventral angle of mesepimeron (Figs 1B-D, 2C). Metepisternum subrectangulate; well developed external efferent system of metathoracic glands, occupying about 1/3 of sclerite (Figs 1B, 2C); evaporative areas contiguous with mesepimeron; peritreme elliptical, raised posteriorly (Fig. 1C,D), positioned anteriorly or medially (Figs 1B, 2C) on sclerite, sometimes more broadly raised, spout-like. Legs elongate (Figs 3, 6, 8, 13). Metafemora greatly elongate, tapered distally (Fig. 3B, 13). Tarsi two-segmented (Figs 6, 8, 13). Pretarsi with weakly (Fig. 2F) to strongly arcuate (Fig. 1E) claws, with (Fig. 2F) or without (Fig. 1E) subapical teeth; spatulate paremipoida; lacking pulvilli or pseudopulvilli (Fig. 1E). Male genitalia: pygophore conical (Figs 1G, 2E), sometimes with pygophoral processes; genital opening oval, dorsal (Fig. 1H) or terminal (Fig. 2E) in orientation; parameres roughly equivalent in size (Fig. 5A,B); sometimes only weakly asymmetrical; left paramere always largest, usually C-shaped (Fig. 5A) to weakly arcuate (Fig. 7A), with apex of shaft hooked (Fig. 5A), sometimes with basal (Figs 7A) or subapical (Fig. 9A) processes; aedeagus with membraneous endosoma (e.g. Figs 5C, 7C 14C, 15C), always with sclerotised strap-like (often looped) basal sclerites; often with digitiform basal sclerites (Figs 5C, 7C, 9C), sometimes with multiple digitiform lobal sclerites (Figs 7C, 9C), less commonly with sclerotised, fan-like lobal sclerites (Figs 5C), with apical margin serrate; sceondary gonopore either undifferentiated (Figs 12C, 14C, 15C, 18C) or with prominent ring-like process with

dentate aperture (Figs 5C, 7C, 9C); ductus seminis short; phallotheca short to moderately large. Female genitalia: sclerotised rings (Figs 10A,C, 16A,C,E, 19A,C) relatively flattened or slightly folded and sometimes with small lobes on outside margin of ring; ventral labiate plate entire or separate, wider than width of ring(s); dorsal labiate plate reflexed mesially dorsal to rings or with scroll-like lateral margins; sometimes sclerotised rings and associated structures asymmetrical; posterior wall (Figs 10B,D, 16B,D,F, 19B,D) with inter-ramal sclerite entire or bilaterally separated; sometimes with one to three pairs of bilaterally separated inter-ramal lobes; dorsal lobe and lateral lobes absent.

DISTRIBUTION. The *Vannius* complex is circumtropical, with centres of endemism in Madagascar, island archipelagos of the south-west Pacific (Fiji, New Caledonia, Vanuatu), the wet tropics of northern Queensland, and the northern Neotropical region. All of the genera are restricted to a major zoogeographical region. Ten species and three genera (*Austrovannius*, *Vanniopsis* and *Vanniusoides*) are endemic to the Australian region (Figs 4, 11, 17).

REMARKS. Gorczyca (1997) erected a new tribe of Miridae, the Vanniini, for *Afrovannius* Gorczyca, *Paracylapus* Carvalho, *Vanniopsis* Poppius, *Vannius* Distant and *Vanniusoides* Carvalho & Lorenzato, which have spatulate parempodia and toothed claws. He removed these genera from the Cylapinae and placed them with the annectant taxon, *Palaucoris* Carvalho, a genus for which Carvalho (1956) established a subfamily with unspecified affinities. Gorczyca (1997) thereby established the following classification: Palaucorinae: Palaucorini (*Palaucoris*) and Vanniini (*Vannius* complex). In contrast, Schuh (1975) regarded the palaucorines as a subtribe of Bryocorinae, and as sister-group to the Eccritotarsina, within the tribe Eccritotarsini.

Gorczyca (1998) questioned his original arrangement, comparing the characters of the Vanniini with selected taxa of Cylapini (*Cylapomorpha migratoria* (Distant) and *Phylocylapus lutheri* Poppius). He recognised 'great similarities' of the body, antennae, tarsi and colour pattern. However, Gorczyca did not clearly restore the Vanniini within the Cylapinae, despite implicitly maintaining their tribal status. Moreover, he argued that there were alternative interpretations, based on potential homoplasy of the observed characters, including the parempodia.

We consider the arrangement of Gorczyca (1997) to be unsupported based on our reappraisal. Toothed-claws occur in Cylapinae, Psallopinae and some Isometopinae (Schuh, 1975, 1976; Schuh & Schwartz, 1984), and is therefore too general to be considered a synapomorphy of Palaucorini + Vanniini. Furthermore, the claw (with deeply notched subapex) of *Palaucoris*, is more elaborate than in the *Vannius* complex, and the putative homology is at best conjectural.

Spatulate parempodia as a synapomorphy for Palaucorinae *sensu* Gorczyca also needs re-analysis. Spatulate parempodia occur within other higher taxa, such as the Deraeocorinae: Termatophylini (e.g. *Arygrotelaeus* Reuter & Poppius — see Cassis, 1995: figs 89, 95), and Phylinae (e.g. *Arafuramiris* Schuh — see Schuh, 1984: fig. 670) but these latter exemplars are not indicative of suprageneric relationships. However, the presence of spatulate parempodia in Palaucorinae *sensu* Gorczyca does appear to be invariant and their homology cannot be falsified at present.

Gorczyca (1997) listed a number of characters additional to the aforementioned pretarsal characters, as a basis for his concept of the Palaucorinae. These include the vertical head and the short labium. The former character occurs in many mirid groups, but most significantly in many of the taxa placed within the Cylapini *sensu* Carvalho. This suggests that the *Vannius* complex is related to taxa within the Cylapini. Moreover, Schuh (1976) showed that Bryocorinae: Eccritotarsini, including *Palaucoris*, possess a vertical head.

The length of the labium has limited phylogenetic value. In most Miridae the labium extends between the middle and hind coxae, and are distinct in comparison to the elongate condition found in most Cylapinae *sensu* Carvalho. Gorczyca (1997) reported that the Palaucorini and Vanniini possess a short labium. Our observations suggest that the length of the labium varies considerably in the *Vannius* complex, varying from the mesocoxae to the gential segments. In contrast, the labium in *Palaucoris* does not extend beyond the middle of the mesocoxae.

In summary, we believe that there is not ample support for the conception of the Palaucorinae as a subfamily comprising *Palaucoris* and the *Vannius* complex. There is considerable homoplasy exhibited in the characters described by Gorczyca (1997, 1998). Pending a phylogenetic

analysis of a larger sample of cylapine taxa we propose that the *Vannius* complex be maintained in the Cylapinae as *incertae sedis* and that its relationship with *Palaucoris* be rejected.

CHECKLIST OF *VANNIUS* COMPLEX

Austrovannius gen. nov.	
platnicki sp. nov.	New Caledonia
scutica sp. nov.	Australia (north Qld)
xepenehense sp. nov.	New Caledonia
Afrovannius Gorczyca, 1997	
annulicornis (Poppius, 1909)	Madagascar
halinae Gorczyca, 1997	Sierra Leone
mahensis (Distant, 1913)	Seychelles
schmitzi (Gorczyca, 1996)	Madagascar
Paracylapus Carvalho, 1952	
insularis Carvalho, 1952	Madagascar
lestoni (Gorczyca, 1996)	Ghana
Vanniopsis Poppius, 1909	
crobylos sp. nov.	Vanuatu
howense sp. nov.	Australia (Lord Howe I)
rufescens Poppius, 1909	New Caledonia, Vanuatu
Vannius Distant, 1883	
crassicornis Poppius, 1909	Bolivia
oculatus Carvalho, 1955	Costa Rica
podager Bergroth, 1922	Brazil
rubrovittatus Distant, 1883	Colombia, Guatemala, Panama
Vanniusoides Carvalho & Lorenzato, 1978	
asprokara sp. nov.	Fiji
brevis (Poppius, 1909)	New Guinea
clypeatus Gorczyca & Konstantinov, 2001	Solomon Islands
melafrons sp. nov.	Australia (north Qld)

KEY TO THE GENERA OF THE *VANNIUS* COMPLEX

1. Labium extending to genital segments; males with longitudinal ridge on ventral surface of pygophore (Fig. 1G) . . . . . *Austrovannius* gen. nov.
   Labium extending at most to fourth abdominal segment; males without ventral ridge on ventral surface of pygophore. 2
2. Head with longitudinal shallow sulcus (Fig. 2A) 3
   Head entire, without sulcus (Fig. 6) 4
3. AI significantly longer than head (Figs 3A,B, 13) . . . . . *Vanniopsis*
   AI equal to or shorter than length of head (Figs 3D, 6, 8) . . . . . *Vannius*
4. Two subapical teeth on tarsal claws; peritreme of external efferent system of metathoracic glands medially oriented on metepisternum . . . . . *Paracylapus*
   One subapical tooth on each tarsal claw (Fig. 2F); peritreme of external efferent system of metathoracic glands anteriorly oriented on metepisternum 5
5. Dorsum with distinct red-orange markings and narrow black markings on head, clavus and hemelytra; femora enlarged basally . . . . . *Afrovannius*
   Dorsum with distinct red-orange markings only; femora narrow . . . . . *Vanniusoides*

Austrovannius gen. nov.
(Figs 1, 3D, 4-10)

ETYMOLOGY. For its restriction to the Australian region and its membership of the *Vannius* complex.

TYPE SPECIES. *Austrovannius scutica* sp. nov., by original designation.

DIAGNOSIS. Staphylinoid (Figs 6, 8); pronotal collar almost obsolete, at most as an impressed line (Figs 6, 8); labium reaching between abdominal sternum VII and genital segments; pronotum reduced and flattened (Figs 6, 8); claws strongly arcuate (Fig. 1E); subapical teeth absent (Fig. 1E); pygophore with longitudinal medial ridge on ventral surface (Fig. 1G); endosoma with basal and lobal sclerites (Figs 5C, 7C, 9C); sclerotised rings (Fig. 10A,C) asymmetrical, large, and with marginal processes; and, posterior wall (Fig. 10B,D) with inter-ramal lobes.

DESCRIPTION. *Colouration*. Body reddish to brown, sometimes with disrupted red markings on dorsum (Figs 3D, 8), lateral aspects of head and thoracic pleura. Metafemora sometimes with red banding. Abdominal venter stramineous to red-fuscous.

Vestiture. Body with sparse to moderate density of soft to stiff (bristle-like) semi-erect to decumbent, simple setae (Fig. 3D).

Texture. Body smooth.

Structure. Small; staphylinoid (Figs 3D, 6, 8); ovoid. Head: vertex flat to weakly convex (Fig. 1A), sometimes with submedial weak depressions. Antennae thread-like, elongate, much longer than body, at least 1.5× longer (Fig. 3D); AI equal to head length (Figs 6, 8), weakly expanded; AII elongate (Figs 6, 8), cylindrical, narrow, a little broader than AIII-AIV; AIII-AIV elongate, very narrow. Labium elongate, extending between abdominal sterna VII and genital segments. Pronotum (Figs 6, 8) transverse, subrectangular, ring-like, small, flat; collar vestigial, at most as thin crease; remainder of pronotum uniform, not subdivided into callosite region and disc; posterior margin rectilinear. Mesoscutum not visible (Figs 6, 8). Scutellum triangular, transverse, small, shorter than pronotum, flat (Figs 6, 8). Proepimeron weakly depressed medially (Fig. 1A). Mesepimeron: metathoracic spiracle (Fig. 1B-D) not exposed; ventral angle of mesepimeron with evaporative bodies. External efferent system of metathoracic glands (Fig. 1B-D) occupying a little more than a third of metepisternum; peritreme elliptical, moderately tumid and raised, positioned

medially on metepisternum, not reaching lateral margin of evaporative area. Metafemora greatly elongate, tapered distally. Pretarsal claws (Fig. 1E,F) strongly arcuate, subapical teeth absent. Male genitalia: pygophore subconical (Fig. 1G,H), with longitudinal medial ridge on ventral surface; genital opening large, ovoid, dorsally oriented; sometimes with flange-like processes dorsoanteriorly to paramere insertions; parameres simple; left paramere (Figs 5A, 7A, 9A) C-shaped to subtriangular, usually elongate, sometimes with basal or subapical process; right paramere (Figs 5B, 7B, 9B) either short or elongate; phallotheca large, subconical; aedeagus (Figs 5C, 7C, 9C) with membraneous endosoma, most often with multiple lobal sclerites, rarely without lobal sclerites, most lobal sclerites digitiform, tapered apically, often with fan-like lobal sclerites, with apices serrate; strap-like basal sclerites present, often with additional digitiform processes; secondary gonopore large, sclerotised, with dentate aperture. Female genitalia: sclerotised rings (Fig. 10A,C) asymmetrical, moderately large to large, folded with pointed processes on lateral margins; ventral labiate plate entire, convoluted; dorsal labiate plate well-sclerotised not as wide laterally as ventral labiate plate; posterior wall (Fig. 10B,D) with inter-ramal sclerite entire and anterior surface with one to three pairs of bilateral inter-ramal lobes.

DISTRIBUTION AND HABITAT. *Austrovannius* is restricted to the southwest Pacific (Fig. 4), and is known from New Caledonia, the Loyalty Islands, and tropical Queensland (Bellenden Ker Range). The three described species are known from leaf litter in rainforests.

REMARKS. *Austrovannius* is the most distinctive genus of the *Vannius* complex, and has a number of notable autapomorphies, including, the short ring-like pronotum (collar vestigial) (Figs 6, 8), ridge-like ventral midline of the pygophore (Fig. 1G), the elongate labium (almost or reaching genital segments), the strongly arcuate tarsal claws, and the elaborate male and female genitalia. The species are all very small, less than 2mm in length, and have an ovoid body, often with disruptive colouration (Fig. 3D). The male genitalia are the most intricate in the *Vannius* complex with the endosoma bearing both basal and lobal sclerites (Figs 5C, 7C, 9C). In addition, the secondary gonopore is strongly sclerotised with a dentate aperture.

As mentioned above the genus contains many undescribed species and are the subject of another paper.

KEY TO THE SPECIES OF *AUSTROVANNIUS*

1. Pronotum and forewings usually concolorous (Fig. 6), either brown or reddish 2
   Pronotum and forewings stramineous with patterned red markings (Figs 3D, 8) 3
2. Pronotum and forewings brown; left paramere (Fig. 5A), without basal process apex hooked; endosoma (Fig. 5C) with two sickle-shaped spiculi attached below secondary gonopore, and two apical fan-like lobal sclerites; New Caledonia . . . . . *platnicki*
   Pronotum and forewings stramineous-red; left paramere (Fig. 7A) with basal process, apex not hooked; endosoma (Fig. 7C) without sickle-shaped spiculi or fan-like lobal sclerites; North Queensland . . . *scutica*
3. Metafemora mostly brown with apex stramineous; endosoma (Fig. 5C) with two basal spiculi, without lobal sclerites; New Caledonia . . . . . *platnicki*
   Metafemora mostly stramineous with submedial and subapical red bands (Figs 3D, 8); endosoma (Fig. 9C) with digitiform and fan-like lobal sclerites, without basal spiculi; Loyalty Islands . . . . . *xepenehense*

Austrovannius platnicki sp. nov.
(Figs 4, 5)

ETYMOLOGY. In honour of Dr Norman Platnick, who was one of the collectors of the type series.

MATERIAL. NEW CALEDONIA. Holotype, ♂, Mount Koghis, 22°11'S 166°31'E, 500m, 23-30 May 1987, R Raven and N Platnick, rainforest pitfalls (MNHP); Paratypes: 6♂♂, same data as holotype (AM, QM); 1♂2♀♀ Mount Koghis, 22°11'S 166°01'E, 500m, 22 November 2000, GB Monteith rainforest sieved litter (QM); 1♂3♀♀, Mount Koghis, 22°11'S 166°01'E, 500m, 22 November 2000, GB Monteith, pyrethrum trunks and logs, 9931 (QM).

DIAGNOSIS. Pronotum and forewings most often stramineous-brown; labium uniformly stramineous, reaching abdominal sternum VII; thoracic pleura dark brown; metafemora dark brown; tibiae stramineous; left paramere (Fig. 5A) sickle-shaped, without basal process, shaft broadly and evenly arcuate; endosoma (Fig. 5C) without lobal sclerities, with pair of bifureate basal sclerites, two basal arcuate spiculi and two apical fan-like plates.

DESCRIPTION. *Colouration*. Body mostly stramineous brown, rarely with red markings on dorsum. Head stramineous to yellow-brown; vertex with an obscure brown (rarely red) subtriangular marking; mandibular and maxillary plates, bucculae, genae and gular mostly stramineous, rarely mostly red, with fuscous

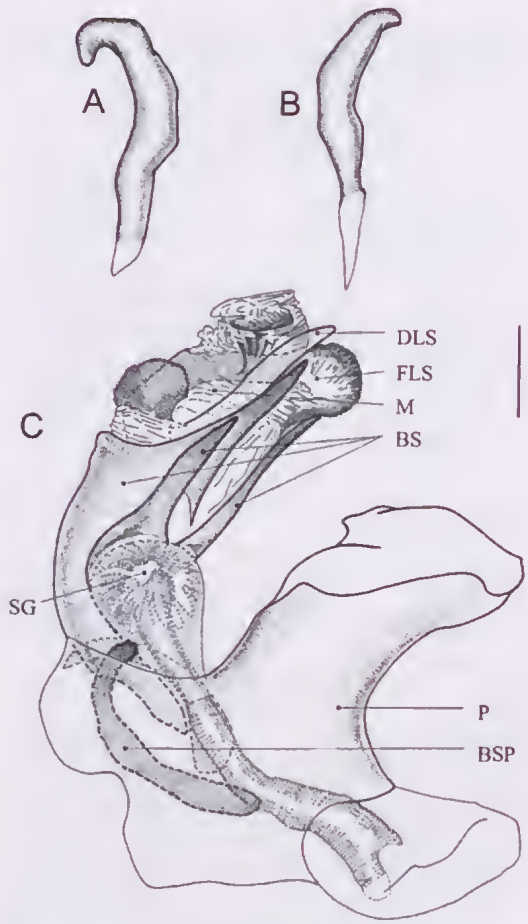

FIG. 5. *Austrovannius platnicki*. A, left paramere; B, right paramere; C, aedeagus. BS = basal sclerites, BSP = basal spiculum, DLS = digitiform lobal sclerite, FLS = fan-like lobal sclerite, M = membaneous sac, P = phallotheca, SG = secondary gonopore. Scale bar = 0.10mm.

highlighting. Labium stramineous to stramineous-brown. Antennae mostly stramineous, AII with an apical whitish annulation. Pronotum stramineous-brown, laterally darker, sometimes laterally red. Thoracic pleura stramineous-brown, sometimes with ventral margin of propleura paler, rarely more uniformly red with fuscous highlighting. Scutellum stramineous, rarely anterior margin with red tinge. Forewings mostly stramineous-brown, rarely with disruptive reddish markings. Legs mostly stramineous-brown; coxae brown; fore and mesofemora stramineous; hind femora darker brown, with apices stramineous; tibiae and tarsi stramineous. Abdomen mostly brown, sometimes pygophore paler ventrally.

Structure. Labium reaching abdominal sternum VII. Male genitalia: left paramere (Fig. 5A) sickle-shaped, without basal process, shaft broadly and evenly arcuate; right paramere (Fig. 5B) arcuate, subequal in size to left paramere, apex weakly angulate; endosoma (Fig. 5C) with two major membraneous lobes, two basal arcuate spiculi, one with apex acute, other with apex serrate, secondary gonopore sclerotised, with aperture dentate, with pair of bifurcate digitiform basal sclerites, with two apical fan-like lobal sclerites, without digitiform lobal sclerites. Female genitalia not examined.

Measurements. 3♂ ♂ BL 1.49-1.92, HW 0.61-0.62, IOD 0.28-0.30, HL 0.34-0.37, PL 0.15-0.17, PW 0.64-0.66, AII 0.98-1.06, LL 0.87-0.96; 1♀ BL 1.88, HW 0.63, IOD 0.30, HL 0.36, PL 0.17, PW 0.66, AII 1.01, LL 1.10.

DISTRIBUTION AND HABITAT. Mid-altitude rainforest in southern New Caledonia, from a single location (Mt Koghis) (Fig. 4). The species is epigaeic, with most specimens collected in pitfall traps or from sieved litter. A series was collected by pyrethrum fogging, from trunks and logs.

REMARKS. *Austrovannius platnicki* is unlike the other species of the genus, in lacking digitiform lobal sclerites. The endosoma (Fig. 5C) is complex however, in possessing bifurcate basal sclerites, apical fan-like lobal sclerites and basal spiculi. The genitalia are most like those of *A. xepenehense*, in possessing fan-like lobal sclerites and basal processes, but the latter is differentiated by having lobal sclerites (cf. Figs 5C and 9C). The parameres of these species are also alike, with both having C-shaped parameres (cf. Figs 5A,B and 9A,B).

These above species are often distinguished externally by colour pattern differences, with most specimens of *A. platnicki* uniformly brown, and *A. xepenehense* with red markings on the dorsum. A single series of *A. platnicki* (reference number 9931) has red markings, similar to those found in *A. xepenehense*, but the male genitalia are clearly conspecific with the other Mt Koghis specimens of *A. platnicki*. Precedence is given to the value of the male genitalia in species level decision-making, because of the complexity of the structures of the endosoma. The species description of *A. platnicki* is primarily based on the 'Raven and Platnick' material because there

FIG. 6. Habitus of *Austrovannius scutica*.

are more specimens and they are in superior condition. The three series were collected at different periods (May and November), which suggests that this species is multivoltine and colour polymorphism may be attributable to generational factors. The female specimens were not examined because there is some doubt about their conspecificity.

Austrovannius scutica sp. nov.
(Figs 1D-H, 4, 6, 7, 10A,B)

ETYMOLOGY. Latin *scutica*, referring to the extremely long whip-like antennae.

MATERIAL. QUEENSLAND. Holotype, ♂, Bellenden Ker Range, 1km S of Cable Tower 6, 17°9'36"S 145°31'48"E, 500m, 17-24 October 1981, 500 metres, Earthwateh and Queensland Museum Survey, rainforest sieved litter, QM Berlesate No. 319, GB Monteith (QM; Registration no. QM T108614). Paratypes: 2♂, same data as holotype, QM Berlesate Nos 315 and 320 (QM); 2♂♂, Bellenden Ker Range, Cableway base station, [17°9'36"S 145°32'24"E], 100m, 17 October-9 November 1981, Earthwateh and Queensland Museum survey, rainforest pitfall trap, GB Monteith (AM; QM).

DIAGNOSIS. This species is distinguished by the following combination of characters: pronotum and forewings red; first labial segment red, LII-IV stramineous; thoracic pleura mostly uniformly red, sometimes more reddish-fuscous; left paramere (Figs 7A) subtriangular, with basal process, apex hooked; right paramere (Fig. 7B) subtriangular with apex hooked; endosoma (Fig. 7C) with seven lobal sclerites; and, posterior wall (Fig. 10B) with one pair of widely separated dorsal inter-ramal lobes.

DESCRIPTION. *Colouration*. Body (Fig. 6) mostly red to reddish-brown with stramineous patches on head, ventral surface of body mostly

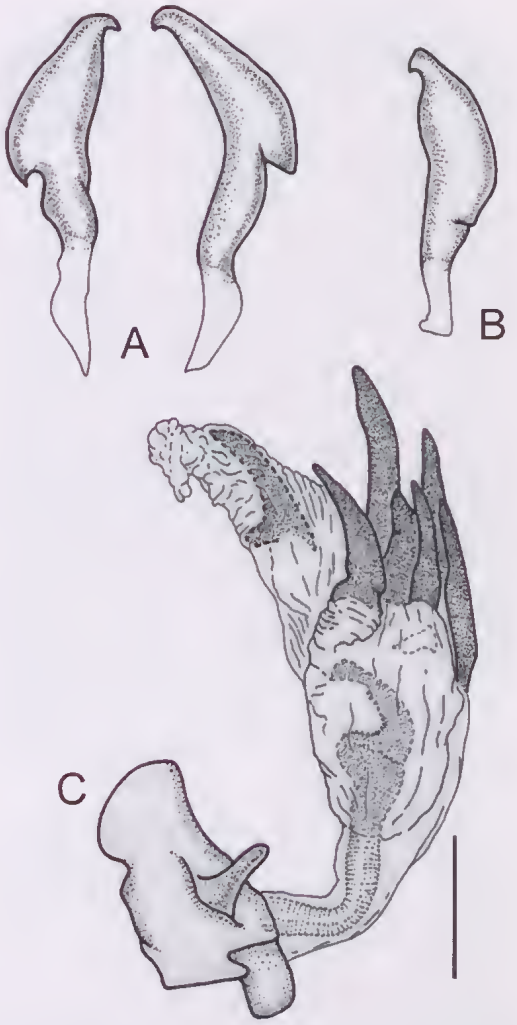

FIG. 7. *Austrovannius scutica*. A, left paramere, lateral view; B, left paramere, mesial view; C, right paramere; D, aedeagus. Scale bar = 0.10mm.

red, sometimes with stramineous or fuscous highlighting. Head stramineous to yellow-brown; posterior margin of vertex occasionally more enbrowned; mandibular plate yellow-brown to fuscous-red; maxillary plate, bucculae, genae and gular most often red. Labium: LI red; LII-IV stramineous. Antennae mostly stramineous; AI sometimes with small red spots basally; AII-AIV sometimes weakly enbrowned. Pronotum: red to reddish-fuscous. Thoracic pleura red or reddish-fuscous. Scutellum stramineous-red to stramineous-fuscous. Forewings mostly stramineous-red, rarely reddish-fuscous. Legs

mostly stramineous; coxae stramineous-red; fore and mesofemora stramineous; metafemora red-brown with stramineous annulations on distal third and apex; tibiae and tarsi stramineous. Abdomen mostly red; male pygophore sometimes stramineous-red ventrally.

Structure. Habitus (Fig. 6). Labium reaching genital segments. External efferent system of metathoracic glands (Fig. 1D). Pretarsus (Fig. 1E,F). Male genitalia: pygophore (Fig. 1G,H); left paramere (Fig. 7A) small, subtriangular, with acute hook-like basal process, apex of shaft hooked; right paramere (Fig. 7B) small, elongate, also with apical and basal hook-like processes; endosoma (Fig. 7C) enlarged, with multilobed membranous sac, one lobe of sac with four elongate lobal sclerites, without basal arcuate spiculi or apical fan-like lobal sclerites. Female genitalia: (Fig. 10A,B) sclerotised rings and labiate plates (Fig. 10A) moderately large, rings attenuated mesially, widely separated, folded, and adhering ventral plate anteriorly; ventral labiate plate entire, anterior margin thickened; dorsal labiate plate obscure; inter-ramal sclerite of posterior wall (Fig. 10B) with ventral margin attenuated, flanking minutely spinose mesial region, with two widely separated, bilaterally sculpted inter-ramal lobes dorsally.

Measurements. 5♂ ♂ BL 1.20-1.40, HW 0.55-0.56, IOD 0.24-0.27, HL 0.27-0.34, PL 0.15-0.18, PW 0.54-0.61, AII 1.18-1.29, LL 0.92-1.10; 1♀ BL 1.58, HW 0.57, IOD 0.26, HL 0.37, PL 0.16, PW 0.63, AII 1.15, LL 1.16.

DISTRIBUTION AND HABITAT. Mid-altitude rainforest in the wet tropics of Queensland (Bellenden Ker Range) (Fig. 4). Epigaeic, with specimens collected either by sieving litter, or in pitfall and flight intercept traps. A single specimen was collected by pyrethrum fogging.

REMARKS. *Austrovannius scutica* is distinguished from *A. platnicki* and *A. xepenehense* by differences in the shape of the parameres (cf. Figs 5A,B, 7A,B and 9A,B) and structure and size of the endosoma (cf. Figs 5C and 9C). Unlike its congeners, *A. scutica*, has a distinct left paramere (Figs 7A); with a basal process and the shaft not broadly arcuate. The endosoma (Fig. 7C) of the latter species is diagnostic, and is small, lacks arcuate spiculi and apical fan-like lobal sclerites, and has seven elongate digitform lobal sclerites. *A. scutica* is also more uniformly red in colour.

FIG. 8. Habitus of *Austrovannius xepenehense*.

Austrovannius xepenchensc sp. nov.
(Figs 3D, 4, 8, 9, 10C,D)

ETYMOLOGY. Types from Xepenehe.

MATERIAL. LOYALTY ISLANDS: Holotype, ♂, Lifou Island, Xepenehe, 20°47'S 167°11'E, 20m, 6 December 2000, GB Monteith, rainforest sieved litter (MNHP). Paratypes: 4♂ ♂ 1♀, same data as holotype (AM; QM).

DIAGNOSIS. Dorsum stramineous with disruptive red markings (Figs 3D, 8); first antennal segment with reddish highlighting; propleura with two red transverse bands; forewings with ten red markings; metafemora stramineous with submedial and subapical red bands; left paramere (Fig. 9A) with subapical triangular process; endosoma (Fig. 9C) with four digitiform and two fan-like lobal sclerites, and basal sclerites, without basal spiculi; sclerotised rings (Fig. 10C) large, folded, with conspicuous lateral lobes; posterior wall (Fig. 10D) with three bilaterally paired inter-ramal lobes on anterior surface of complete inter-ramal sclerite .

DESCRIPTION. *Colouration*. Body yellow-brown to stramineous, with red markings on dorsum (Fig. 3D, 8). Head mostly stramineous; vertex with reddish markings; frons and genae with red markings, often bounding antennifers; postclypeus with reddish tinge; genae posteriad of maxillary plate with red spot. Labrum mostly stramineous, sometimes with reddish highlighting. Labium: LI mostly red, remainder stramineous to stramineous-brown, with apex of LIV with fuscous highlighting. Antennae: AI stramineous with reddish highlighting (Fig. 3D);

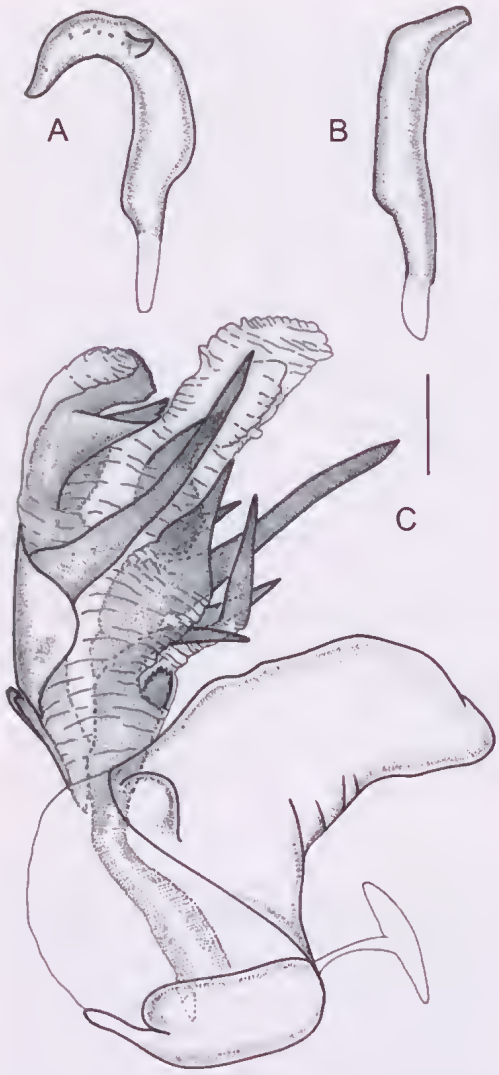

FIG. 9. *Austrovannius xepenehense*. A, left paramere; B, right paramere; C, aedeagus. Scale bar = 0.10mm.

AII-AIV dark brown, apex of AII with whitish apical band. Pronotum mostly stramineous with reddish markings (Fig. 3D); collar with medial red transverse marking; disc laterally and mediposteriorly with red markings. Scutellum most often stramineous, sometimes with reddish highlighting. Forewings with 10 red markings (Fig. 3D); each wing with pair sub-basally, pair submedially, single spot apically. Proepisternum fuscous-red; proepimeron with two transverse bands of fuscous-red. External efferent system of metathoracic glands stramineous, remainder of metepisternum red to fuscous-red. Legs mostly

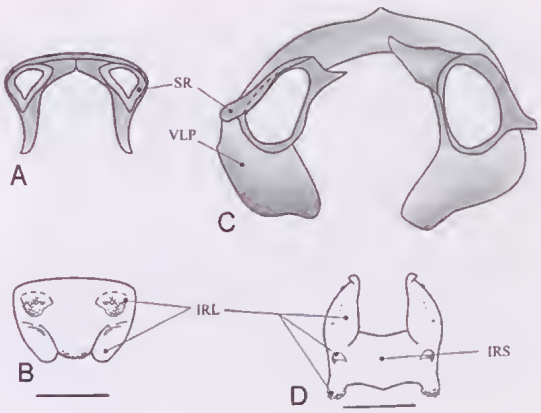

FIG. 10. Female genitalia. *Austrovannius scutica* A, selerotised rings; B, posterior wall; *Austrovannius xepenehense*: C, selerotised rings; D, posterior wall. IRL = inter-ramal lobe, IRS = inter-ramal selerite, SR = selerotised ring, VLP = ventral labiate plate. Scale bar = 0.25mm.

stramineous to light-brown, sometimes with red highlighting; metafemora with submedial and subapical red bands (Fig. 3D); tibiae often stramineous-red.

Structure. Habitus (Figs 3D, 8). Labium reaching abdominal sternum VII. Male genitalia: pygophore with small flange-like processes anterodorsally to paramere insertions; left paramere (Fig. 9A) C-shaped, with subapical triangular process, shaft evenly arcuate with apex hook-like; right paramere (Fig. 9B) sublinear with apex angulate; endosoma (Fig. 9C) bilobed, each subtended by basal processes, one a multifurcate process with four arms, the other with an elongate digitform process; four elongate digitform and one fan-like (with serrated apex) lobal selerites. Female genitalia: selerotised rings (Fig. 10C) large, folded, narrowly separated, attenuated mesially, anterior margin asymmetrically convoluted and attached to dorsal labiate plate; posterior wall (Fig. 10C) with three bilaterally paired inter-ramal lobes on anterior surface of complete inter-ramal selerite, dorsal pair pointed, prominently projecting above dorsal margin of inter-ramal selerite equal to height of selerite, middle pair pointed, short, ventral pair blunt with sculptured surface.

Measurements. 4♂ ♂ BL 1.35-1.50, HW 0.58-0.60, IOD 0.29-0.30, HL 0.31-0.32, PL 0.15-0.17, PW 0.63-0.65, AII 1.10-1.20, LL 0.98-1.03; 1♀ BL 1.75, HW 0.65, IOD 0.30, HL 0.33, PL 0.19, PW 0.68, AII 1.00, LL 1.05.

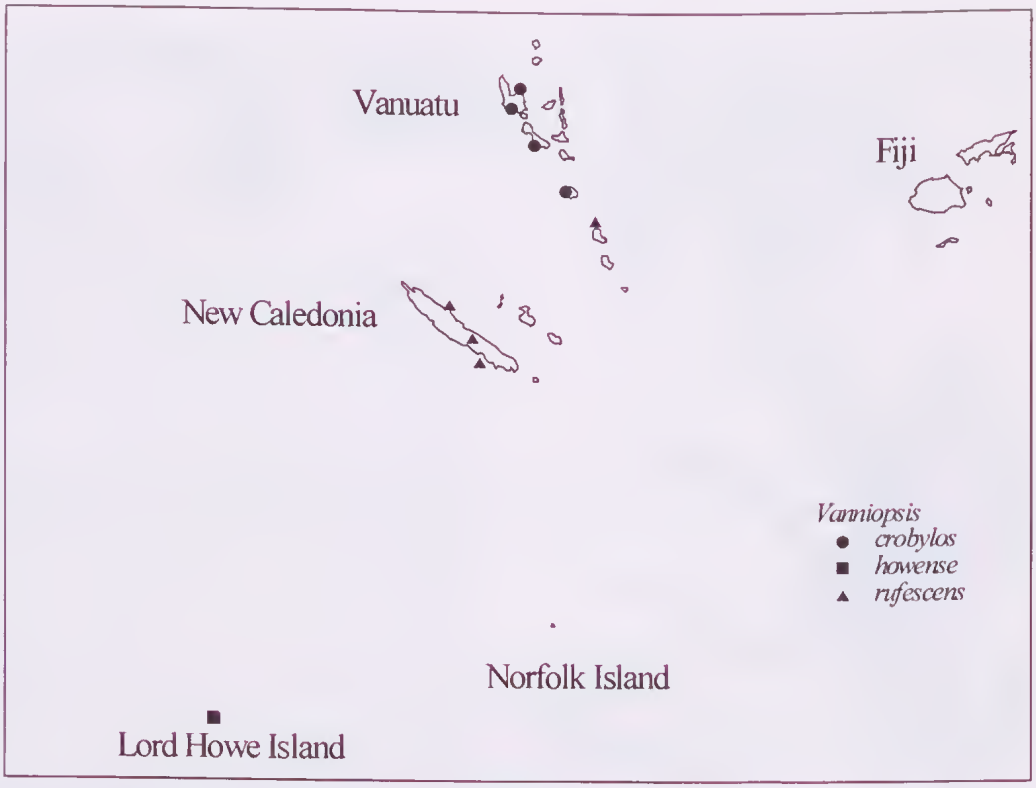

FIG. 11. Distribution map of *Vanniopsis*.

DISTRIBUTION AND HABITAT. From two lowland rainforest sites on Lifou Island (Loyalty Islands) (Fig. 4), amongst leaf litter, and on tree trunks and fallen logs. These specimens have been collected near sea level.

REMARKS. The species is noteworthy for its disruptive colouration (Fig. 3D) and distinctive male aedeagus (Fig. 9C). The endosoma resembles *A. platnicki* in possessing prominent basal processes and apical fan-like lobal sclerites (cf. Figs 5C and 9C). It differs from it by having digitiform lobal sclerites, this latter condition also occuring in *A. scutica*. The left parameres of *A. xepenehense* and *A. platnicki* are alike in being C-shaped, but the former species has a small subapical triangular process (cf. Figs 5A and 9A).

Vanniopsis Poppius, 1909

Vanniopsis Poppius, 1909: 17 (sp. nov.); Carvalho, 1957: 33 (catalogue); Schuh, 1995: 39 (catalogue); Gorczyca, 1997: 519, 540-542, figs 8 and 16 (description).

TYPE SPECIES. *Vanniopsis rufescens* Poppius, 1909, by original designation.

DIAGNOSIS. Head subtriangular (Figs 2A, 13); frons prominent (extending beyond eyes); AI longer than head (Figs 3C, 13); AI compressed and arcuate, much longer than head, with dense distribution of bristle-like setae; AII banded (Fig. 3C); pronotal collar flat and broad (Fig. 3C, 13); tarsal claws weakly arcuate (Fig. 2F); subapical teeth present (Fig. 2F); endosoma (Figs 12C, 14C, 15C) membraneous, usually with paired looped strap-like basal sclerites, secondary gonopore undifferentiated; phallotheca short; parameres strongly asymmetrical; left paramere (Figs 12A, 14A, 15A) large, C-shaped, tapered apically; right paramere (Fig. 16A,C,E) smaller than left paramere, sublinear, apex of shaft tapered; sclerotised rings (Figs 12A, 14A, 15A) widely separated, ovoid, flattened mesially; and, posterior wall (Fig. 16B,D,F) simple, with small, paired inter-ramal sclerites, without inter-ramal lobes.

DESCRIPTION. *Colouration*. Head and pronotum mostly brown, with forewings either reddish, or stramineous to brown with reddish to orange-red markings (Figs 3C, 13). Head often

brown, with posterior margins of vertex with reddish markings; frons often pale yellow to light brown; clypeus either pale yellow to red; bucculae, mandibular and maxillary plates, and genae either pale yellow or red. Antennae: AI either mostly stramineous with reddish markings or red; AII banded (Fig. 3C), mostly brown with basal, medial and apical yellow bands; AIII mostly brown with apical yellow band; AIV brown. Labium mostly stramineous to stramineous-orange, with LI sometimes with red highlighting, LIV sometimes with fuscous highlighting. Thoracic pleura mostly red, sometimes propleura more brown. Legs mostly stramineous; metafemora with subapical reddish marking. Pronotum mostly brown, sometimes with longitudinal medial stramineous line. Scutellum mostly brown, sometimes apex stramineous. Forewings (Fig. 3C) either mostly red to orange-red with stramineous to hyaline regions on corium or in staphylinoid species brown with four reddish markings; cuneus red or orange-red with apex red; membrane fumose. Abdominal venter red to orange-red.

Vestiture. Dorsum usually with short dark semi-erect, bristle-like setae. Frons sometimes with dense distribution of elongate semi-erect setae (Figs 3C, 13).

Texture. Mostly smooth, with forewings often weakly rugose.

Structure. Macropterous (Fig. 3C) or staphylinoid (Fig. 13); elongate to elongate-ovoid. Head: (Fig. 2A,B) vertex weakly convex to flat, with shallow longitudinal sulcus. Antennae elongate, thread-like, subequal (Fig. 3C) to or longer than body (Fig. 13); AI (Figs 3C, 13) thickened, bilaterally compressed, arcuate, longer than head length; AI longer than AIII. Labium extending to metacoxae. Pronotum transverse; campanulate or rectangulate; collar broad, flat. Mesoscutum exposed or concealed. Scutellum flat to weakly convex, subequal in length to pronotum. Hemelytra: corium broad, moderately convex; cuneus elongate. Thoracic pleura: (Fig. 2C) procpimeron flat to weakly depressed medially; metathoracic spiracle exposed, bounded by evaporative bodies; external efferent system of metathoracic glands moderately developed, occupying about 1/3rd of segment; peritreme tumid, orientated anteriorly to medially, not reaching dorsal margin of evaporative area, sometimes peritreme strongly raised and tumid, and external system spout-like. Legs: metafemur elongate (Fig. 3C) and tapered distally; tarsal claws weakly arcuate; claws with subapical teeth. Male genitalia: left paramere (Figs 12A, 14A, 15A) large, C-shaped, tapered apically; right paramere (Figs 14B, 15B) smaller, sublinear, apex of shaft tapered; endosoma (Figs 12C, 14C, 15C) membraneous, with or without selerotised spinose fields, without lobal selerites, usually with paired looped strap-like basal selerites supporting membrane; secondary gonopore undifferentiated; phallotheca short. Female genitalia: selerotised rings (Figs 16A,C,E) weakly differentiated, widely separated, ovoid, flattened mesially; posterior wall (Figs 16B,D,F) simple, with small, paired separated narrow, lunate-shaped inter-ramal selerites, without inter-ramal lobes.

DISTRIBUTION. New Caledonia, Vanuatu and Lord Howe Island (NSW, Australia) (Fig. 11).

REMARKS. *Vanniopsis* is best differentiated by its first antennal segment and the aedeagus. The most distinctive feature of this genus is the arcuate, elongate (much longer than head) and bilaterally compressed first antennal segment (Figs 3C, 13), which also has dense bristle-like decumbent setae. In other taxa of the *Vannius* complex, the first antennal segment is a little larger or subequal to the head length, and is never compressed and arcuate, or has the vestiture described above.

There are superficial reasons for erecting a new genus for *V. howense*, because of its morphological distinctiveness; namely, the staphylinoid body and correlated reductions of the pronotum and scutellum, as well as the elongate antennae (Fig. 13). However, this species is clearly congeneric with its macropterous relatives, based on the aforementioned characters (first antennal segment and aedeagus).

KEY TO THE SPECIES OF *VANNIOPSIS*

1. Macropterous (Fig. 3C); antennae subequal in length to the body; genital opening of male pygophore dorsal in orientation 2

   Staphylinoid (Figs 2D, 13); antennae significantly longer than body; genital opening of male pygophore terminal in orientation (Fig. 2E); Lord Howe Island . . *howense*

2. Frons densely setate; clypeus, mandibular and maxillary plates stramineous; left paramere with subapical flange (Fig. 12A); three endosomal basal selerites, not looped (Fig. 12C); Vanuatu . . . . . *crobylos*

   Frons with sparse distribution of short decumbent setae; clypeus, mandibular and maxillary plates red; two pairs of looped endosomal basal selerites (Fig. 15C); New Caledonia, Vanuatu. . . . . *rufescens*

Vanniopsis crobylos sp. nov.
(Figs 11, 12, 16A,B)

ETYMOLOGY. Greek *krobylos*, referring to the tuft of hair on the head.

MATERIAL. VANUATU. Holotype, ♂ Malekula I[sland], South West Bay, [16°30'S 167°26'E], 300-350m, 2 October 1971, P. Cochereau Roy[al] Soc[iety] Percy Sladen Expedition, beating trees and sweeping grasses, forest (SAMA). Paratypes. ♀ same data as holotype (SAMA); 1♀, Espiritu Santo I[sland] (SW), below Namatasopa, [15°31'S 166°49'E], 250m, 1 September 1957, JL Gressitt (BPBM); 1♀, Efate I[sland] (NW), Limestone Plateau N of Maat, [17.6833°S 168.25°E], 100m, 19 August 1957, JL Gressitt (BPBM); 1♀, Santo I[sland], Iakabone [Iakobone] N of Port Olry, [15°01'S 167°03'E], 40-200m, 21-22 October 1981, JL Gressitt on *Elastostemma* [*sic*] (BPBM)

DIAGNOSIS. Macropterous; forewings rugose; frons densely hirsute; vertex with shallow longitudinal suleus; AI densely hirsute; collar present; AII banded; pronotum campanulate; posterior margin of pronotum bisinuate; mesoscutum exposed; peritreme raised, anteriorly oriented; endosoma with three basal sclerites, membrane reduced (Fig. 12C); and, left paramere (Fig. 12A) with subapical flange.

DESCRIPTION. *Colouration*. Body mostly pale red, with stramineous to stramineous-orange markings. Head brown, with posterior margin of vertex with red markings; clypeus, mandibular and maxillary plates, genae and gular stramineous, sometimes genae posterior to eyes red. Antennae: AI red, sometimes stramineous-red; AII banded, dark brown with medial and apical stramineous bands, with base minutely stramineous; AIII mostly brown with apical yellow band; AIV brown. Labium stramineous to yellow-orange, apex of IV sometimes enbrowned. Pronotum brown. Thoracic pleura red. Mesoscutum brown to red-brown. Scutellum stramineous-brown to orange-brown. Hemelytra mostly red, sometimes with exocorium broadly stramineous and translucent; cuneus mostly red, with apex and medial angle stramineous; membrane fumose, veins red. Legs mostly stramineous; coxae stramineous to red-stramineous; metafemora with subapical red marking. Abdomen mostly red; ovipositor stramineous to stramineous-brown.

Texture. Pronotum and hemelytra rugose.

Vestiture. Dorsum with moderate distribution of simple, fine, erect, elongate, dark setae. Frons with a dense tuft of elongate bristle-like setae.

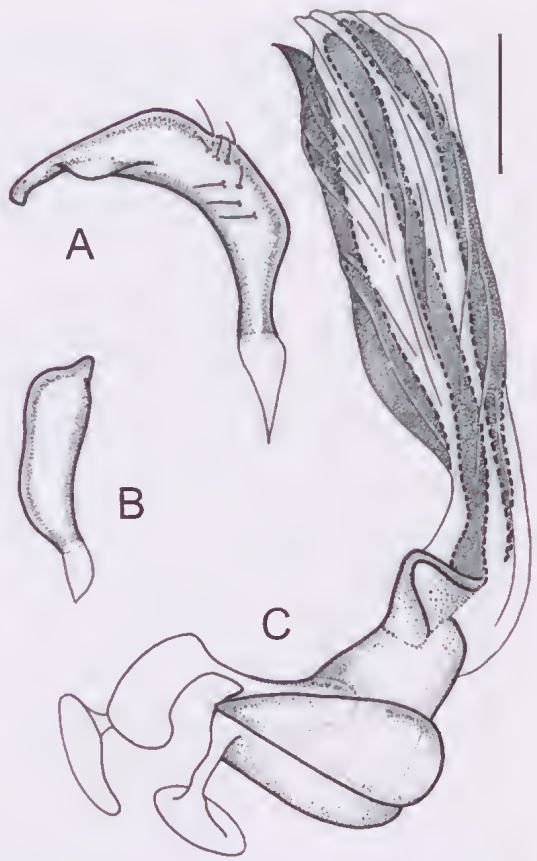

FIG. 12. *Vanniopsis crobylos*. A, left paramere; B, right paramere; C, aedeagus. Scale bar = 0.10mm.

Structure. Macropterous; elongate. Antennae subequal in length to body. Labium extending to apices of metacoxae. Pronotum campanulate; collar broad, anterior margin rectilinear; posterior margin bisinuate. Mesoscutum exposed. Scutellum as long as wide. External efferent system of metathoracic glands spout-like; peritreme anteriorly oriented. Hemelytra: strongly depressed at corial fracture; cuneus narrow and elongate. Male genitalia: pygophore subconical, genital opening large, ovoid, dorsally directed; left paramere (Fig. 12A) small, elongate, subrectangular, broadly expanded subapically, flangelike with hook-like apex; right paramere (Fig. 12B) small, subrectangular, lateral margin moderately emarginate, acute apical process coplanar with remainder of shaft; endosoma (Fig. 12C) with three strap-like basal sclerites supporting thin membranous sac, secondary gonopore undifferentiated. Female genitalia: sclerotised rings (Fig. 16A) moderately

small, semi-elliptical, mesial margin flattened; ventral labiate plate separated, convex anteriorly, flattened mesially; dorsal labiate plate scroll-like laterally; posterior wall (Fig. 16B) with bilaterally paired, thin inter-ramal sclerites on dorsal margin.

Measurements. 1♂ BL 3.82, HW 0.68, IOD 0.26, HL 0.38, PL 0.50, PW 0.95; 4♀♀ BL 3.74-4.01, HW 0.62-0.66, IOD 0.24-0.26, HL 0.37-0.41, PL 0.50-0.60, PW 1.00-1.07, AII 1.15-1.24, LL 0.90-1.24.

DISTRIBUTION AND HABITAT. From three islands of Vanuatu (Fig. 11). A single specimen has been collected on *Elatostema* sp. [as *Elastostemma*] (Urticaceae). The two specimens from Malekula Island were taken from vegetation. These data suggest that *V. crobylos* are 'up-on-plants', and occupy a different habitat than *V. howense*, a known epigaeic species.

REMARKS. *V. crobylos* and *V. rufescens* are morphologically alike, with both species being macropterous and primarily red in colour. The former species can be recognised readily by the hirsute frons and the pale ventral lateral aspect of the head. The male genitalia are significantly different, with the aedeagus of *V. crobylos* reduced, whereas the endosoma of *V. rufescens* (cf. Figs 12C and 15C) is an enlarged multifurcate membranous sac, that has paired looped basal sclerites and spinose fields. The latter endosomal condition and the parameres are most similar to those found in *V. howense* (cf. Figs 12A and 14A).

Vanniopsis howense sp. nov.
(Figs 2, 11, 13, 14, 16C,D)

ETYMOLOGY. For its geographical location.

MATERIAL. LORD HOWE ISLAND. Holotype, ♂, base of Intermediate Hill, 31°33'S 159°4'48"E, 6 December 2000, G Cassis (AM). Paratypes: 4♂♂ 2♀♀ 11 juveniles, same data as holotype; 1♂ 2♀♀ 2 juveniles, Goat House track at creek bed, 31°33'S 159°4'E, 5 m, 8 December 2000, G Cassis, ex fallen leaves of *Howea fosteriana* (AM); 6 juveniles, base of 'Round Face' Mt Lidgbird, Far Flats, 31°34'9"S 159°4'35"E, 27 November 2000, CBCR survey, ex leaf litter, Broad Megaphyllous Closed selerophyll forest – *Howea belmoryana* habitat, site LHI36L (AM); 2 juveniles, N bank of Rocky Run Creek at junction of W costal trail to Boat Harbour, 31°33'19"S 159°5'33"E, 21 November 2000, CBCR survey, ex leaf litter, Broad Megaphyllous Closed selerophyll forest – *Pandanus* habitat, site LHI24L (AM); 2 juveniles, S end of Salmon Beach, vicinity of Little Island, 31°34'8"S 159°4'28"E, 27 November 2000, CBCR survey, ex leaf litter, Broad Megaphyllous Closed selerophyll forest –

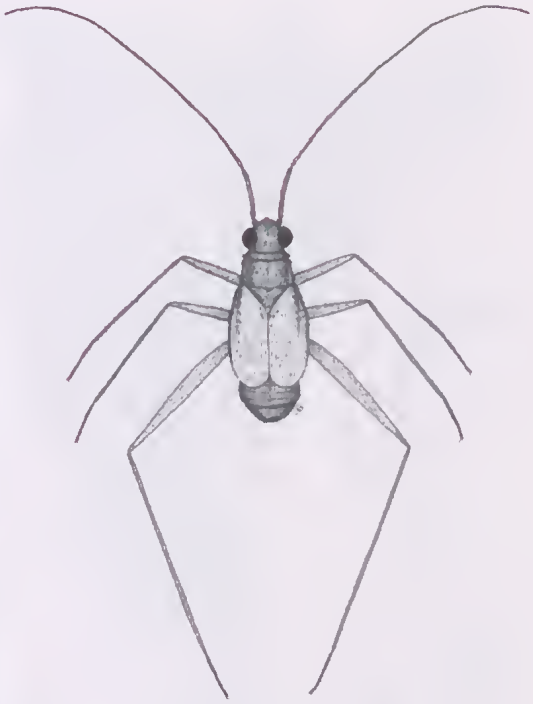

FIG. 13. Habitus of *Vanniopsis howense*.

Howea fosteriana habitat, site LHIS35L (AM); 1 juvenile, Mount Gower walking track, 31°35'12"S 159°4'35"E, 28 November 2000, CBCR survey, ex leaf litter, closed gnarled Mossy Forest - *Bubbia/Dracophyllum*, site LHI50L (AM); 2♂♂ 5♀♀, behind Leanda-Lei, [31°53'S 159°07'E], 45 m, 6 November 1979, GB Monteith, ex leaf litter, ealeareous soil Broad Megaphyllous Closed selerophyll forest – *Howea fosteriana* habitat (QM).

DIAGNOSIS. Staphylinoid (Figs 2D, 13); forewings stramineous with red disruptive colouration; frons sparsely setate; antennae significantly longer than body (Fig. 13); pronotum (Fig. 2A) rectangulate, posterior margin rectilinear; pronotal collar moderately broad, anterior margin convex; mesoscutum concealed; legs greatly elongate; abdomen fuscous and polished; left paramere (Fig. 14A) without processes or flange; right paramere (Fig. 14B) truncate subapically with acute apex.

DESCRIPTION. *Colouration.* Body mostly stramineous-brown to brown, with banded antennae, pale legs, and fuscous abdomen. Head brown to fuscous, sometimes with obscure circular to linear stramineous markings on medial aspect of vertex, sometimes extending to inner margins of eyes. Clypeus, bueculae, mandibular

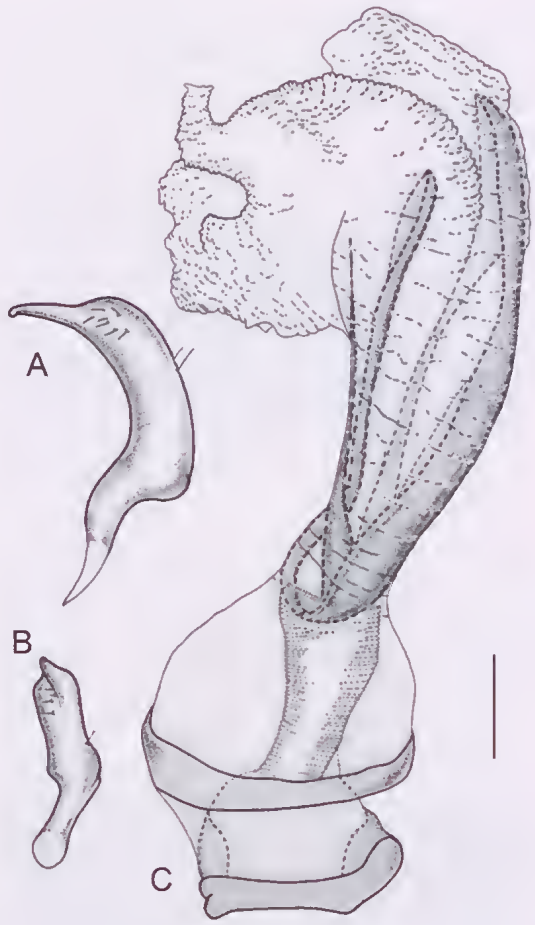

FIG. 14. *Vanniopsis howense*. A, left paramere; B, right paramere; C, aedeagus. Scale bar = 0.10mm.

and maxillary plates, genae and gular red to fuscous-red. Antennae: AI stramineous-red; AII mostly brown, with stramineous annulations basally, medially and apically, occasionally with reddish highlighting; AIII brown with apex stramineous. Pronotum brown to fuscous, most often with medial longitudinal stramineous marking; posterior margin occasionally with red highlighting. Scutellum fuscous, commonly with medial longitudinal stramineous marking, contiguous with pronotal medial marking, posterior quarter to third stramineous. Forewings stramineous to fuscous, with broad red markings medially and on medial margins. Legs stramineous; sometimes basal third of coxae fuscous; metafemora with subapical to apical red marking. Thoracic pleura and abdomen usually fuscous to red-fuscous. Abdomen fuscous-red to fuscous.

Texture. Dorsum smooth; abdomen polished.

Vestiture. Dorsum with moderate density of simple stout dark semi-erect setae. Frons without dense tuft of setae.

Structure. Habitus (Fig. 13). Staphylinoid (Figs 2D, 13). Pronotum (Fig. 2B) subrectangular; posterior margin rectilinear; pronotal collar moderately broad, anterior margin convex. Mesoscutum concealed. Labium reaching apices of metacoxae. Legs greatly elongate. Male genitalia: pygophore (Fig. 2E) subconical, genital opening large, ovoid, terminally oriented; left paramere (Fig. 14A) small, elongate, moderately elongate with hook-like apical process; right paramere (Fig. 14B) short truncate subapically with acute apical process coplanar with remainder of shaft; endosoma (Fig. 14C) with paired looped basal sclerites supporting membrane, secondary gonopore indistinguishable. Female genitalia: sclerotised rings (Fig. 16C) moderately large, semi-elliptical, mesial margin flattened; ventral labiate plate separated, pointed anteriorly flattened mesially; dorsal labiate plate folded dorsal to rings; posterior wall (Fig. 16D) with two bilateral pairs of thin inter-ramal sclerites.

Measurements. 5♂♂ BL 2.23-2.61, HW 0.55-0.66, IOD 0.27-0.30, HL 0.38-0.41, PL 0.39-0.43, PW 0.63-0.70, AII 1.46-1.72, LL 1.12-1.26; 5♀♀ BL 2.49-3.08, HW 0.64-0.69, IOD 0.30-0.31, HL 0.40-0.46, PL 0.41-0.47, PW 0.75-0.81, AII 1.41-1.56, LL 1.25-1.32.

DISTRIBUTION AND HABITAT. Primarily in lowland rainforest on Lord Howe Island (Fig. 11), in a range of vegetation classes (see Pickard, 1983 for floristics). A few specimens were also encountered in high altitude sites, in closed wet forests, including the *Bubbia/Dracophyllum* vegetation type of Mt Gower. One of us [GC] collected a large series of *V. howense* in Kentia palm habitat (*Howea fosteriana*), where it was found amongst fallen palm litter, in association with other heteropterans (*Atisne* sp. [Reduviidae], *Acaraptera* sp. [Aradidae] and rhyparochromid species). Their microhabitat was characterised by rotting leaf mould and abundant fungal mycelia.

REMARKS. *Vanniopsis howense* is distinct within the genus. Much of its distinctiveness is attributable to modifications that are commonly correlated with wing shortening, namely the compact body, simple pronotum (Fig. 2A) (short and subrectangular, narrower collar) and

scutellum (short and transverse). Like much of the epigaeic insect fauna of Lord Howe Island, this species is flightless and there are no known macropterous specimens.

Unlike *V. crobylos* and *V. rufescens*, this species has extremely elongate antennae (much longer than the body) and legs (Fig. 13). However, the state of the first antennal segment (compressed, arcuate, elongate and densely setate) (Fig. 13), is sufficient for its inclusion within *Vanniopsis*, as this is a putative synapomorphy for the genus. In addition, the simple male endosoma (lacking lobal sclerites and undifferentiated secondary gonopore) (Fig. 14C), is shared by the three constituent species of the genus. It should be noted however, that this endosomal type is also found in some species of *Vanniusoides*.

Vanniopsis rufescens Poppius, 1909
(Figs 3C, 11, 15, 16E,F)

Vanniopsis rufescens Poppius, 1909: 17 (sp. nov.); Bergroth, 1920: 72 (list); Carvalho, 1952: 50 (type species); Carvalho, 1957: 33 (catalogue); Schuh, 1995: 39 (catalogue); Gorczyca, 1997: 540 (description)

MATERIAL. NEW CALEDONIA: 1♂, Mt Koghi[s], 22°11'S 166°01'E, 400m, 12-14 November 1986, RL Brown black light trap (BPBM); 1♂, Mt Koghi[s], 22°11'S 166°01'E, 15 February 1963, NLH Krauss (BPBM); 1♀, 7km S of Koh, 21°32'57"S 165°50'00"E, 31 January 1963, CM Yoshimoto (BPBM); 1♂ 2♀♀ 1 larva, 20°40'S 165°13'E, Ponandou intake, 100 m, 25 November 2001, GB Monteith, pyrethrum tree trunks (QM); VANUATU: 1♂, Erromanga Island, Port Narevin, 18°27'S 169°03'E sea level, 25 August 1979, ferns along streams (BPBM).

DIAGNOSIS. Macropterous (Fig. 3C); dorsum weakly rugose; frons sparsely hirsute; pronotum (Fig. 3C) campanulate, posterior margin bisinuate; pronotal collar broad, anterior margin rectilinear; mesoscutum exposed; peritreme moderately spout-like; two pairs of looped basal sclerites; left paramere (Fig. 15A) with basal and subapical processes; and, right paramere (Fig. 15B) with sub-basal process.

DESCRIPTION. *Colouration*. Body mostly pale red, sometimes with stramineous to stramineous-orange markings (Fig. 3C). Head stramineous-brown to brown, with posterior margin of vertex with red markings; frons and medial aspect of clypeus stramineous; lateral margins of clypeus, mandibular and maxillary plates, and genae red to red-orange; gular orange. Antennae: AI red; AII banded, dark brown with medial and apical stramineous bands, with base minutely stramineous; AIII mostly brown with apical stramineous band; AIV brown. Labium mostly orange-brown; LI most often with red highlighting or more uniformly red; apex of LIV enbrowned. Thoracic pleura mostly red, often with propleura more brown to orange-brown with red highlighting. Mesoscutum and scutellum red to red-brown, sometimes with orange highlighting. Hemelytra mostly red, sometimes with lateral margins of clavus and exocorium more orange-red, or more variolate (Fig. 3C); medial angle of endocorium posteriad of claval commissure sometimes stramineous; cuneus orange-red, sometimes subapically red, sometimes apex and medial angle stramineous; membrane fumose; membrane veins red. Legs mostly stramineous to stramineous-orange; foretibiae sometimes with red highlighting distally; apical 1/4 of metafemora with red highlighting. Abdomen mostly red basally, more orange laterally and posteriorly.

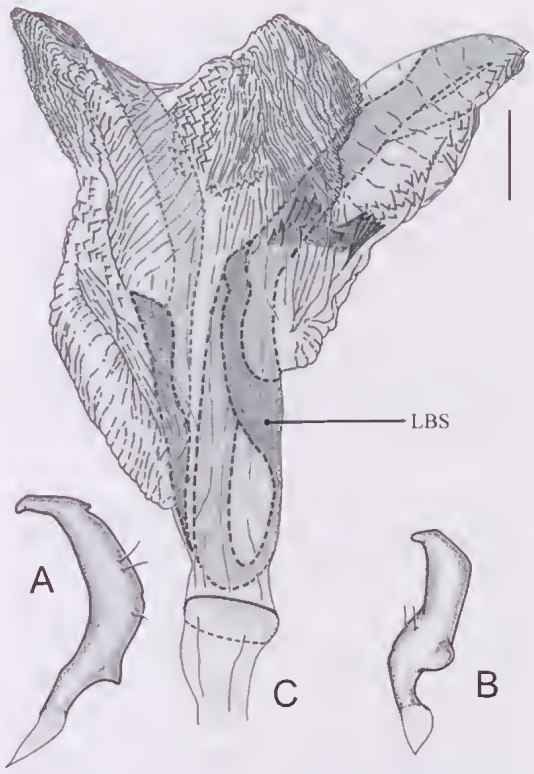

FIG. 15. *Vanniopsis rufescens*. A, left paramere; B, right paramere; C, aedeagus. LBS = looped basal sclerite. Scale bar = 0.10mm.

Texture. Dorsum weakly rugulose.

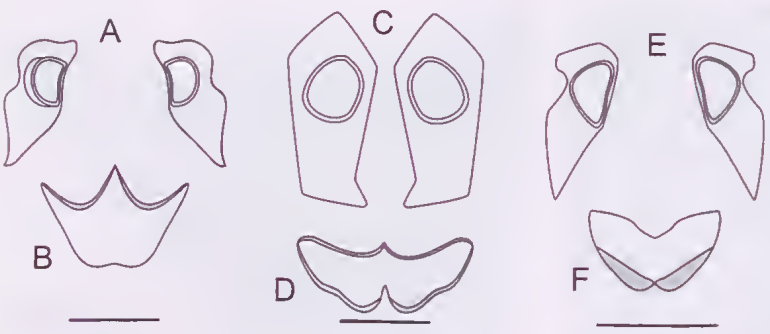

FIG. 16. Female genitalia. *Vanniopsis crobylos*. A, sclerotised rings; B, posterior wall; *Vanniopsis howense*; C, sclerotised rings; D, posterior wall; *Vanniopsis rufescens*; E, sclerotised rings; F, posterior wall. Scale bars, A-D = 0.25mm ; E-F = 0.20mm.

Vestiture. Head, pronotum and hemelytra with moderate to sparse distribution of elongate, simple, dark, erect, setae.

Structure. Habitus (Fig. 3C); Macropterous; elongate. Antennae subequal in length to body (Fig. 3C). Labium extending to apices of metacoxae. Pronotum (Fig. 3C) campanulate; collar broad, anterior margin rectilinear; posterior margin bisinuate. Mesoscutum exposed. Scutellum as long as wide. External efferent system of metathoracic glands spout-like; peritreme anteriorly oriented. Hemelytra: strongly depressed at corial fracture; cuneus narrow and elongate. Male genitalia: pygophore subconical; genital opening moderately large, subovoid, dorsally oriented; left paramere (Fig. 15A) small, elongate sensory lobe slightly produced, subapical dorsal margin with small tubercle, hook-like process apically; right paramere (Fig. 15B) small, sensory lobe slight expanded, subapical region slightly expanded dorsally, pointed apical process coplanar with remainder of shaft; endosoma (Fig. 15C) with two looped basal sclerites supporting membranes, also areas with spinose fields; secondary gonopore indistinguishable. Female genitalia: sclerotised rings (Fig. 16E) moderately large, widely separated, semi-elliptical, mesial margin flattened; ventral labiate plate separated, somewhat truncate anteriorly, flattened mesially, lateral margin excavated; dorsal labiate plate asymmetrically scroll-like laterally, right side larger than left; posterior wall (Fig. 16F) with bilaterally paired, thin inter-ramal sclerites on ventral margin.

Measurements. 3♂♂ BL 3.60-3.75, HW 0.61-0.62, IOD 0.22-0.23, HL 0.35-0.39, PL 0.48-0.50, PW 0.88-0.94, AII 1.26-1.28, LL 1.02-1.08; 3♀♀ BL 3.63-3.82, HW 0.60-0.63, IOD 0.22-0.23, HL 0.32-0.36, PL 0.48-0.50, PW 0.90-0.98, AII 1.07-1.20, LL 1.05-1.15.

DISTRIBUTION AND HABITAT. Vanuatu and New Caledonia (Fig. 11), with the majority of specimens collected from the latter. This species is known from the Northern (Espiritu Santo Island) and Southern districts (Erromanga Island) of Vanuatu, which spans much of the latitudinal range of the archipelago. In contrast, *V. crobylos* is restricted to islands of the Central and Northern districts of the same archipelago. *V. rufescens* is known from sea level to mid-altitude (400m) localities.

This species has been collected on ferns in a riparian habitat and from tree trunks. As with *V. crobylos*, these data suggest that *V. rufescens* is not epigaeic.

REMARKS. *V. rufescens* was described by Poppius (1909) from a single specimen collected from Espiritu Santo Island (Vanuatu). According to Gorczyca (1997), the specimen is badly damaged, with the abdomen missing. We have not been able to examine the holotype, however Gorczyca's description refers to the lateral and ventral aspects of the head as red in colour. This is the condition found in the specimens we have identified as *V. rufescens*, which distinguishes it from our new species, *V. crobylos*, which has these components of the head stramineous in colour.

These two species are alike but can be differentiated by the aforementioned head colour differences and the autapomorphic head vestiture in *V. crobylos*. These differences are supported by significant differences in the parameres (cf. Figs 12A,B and 15A,B) and aedeagus (cf. Figs 12C and 15C).

The sympatry of these two species in the Vanuatu archipelago (Espiritu Santo Island) is noteworthy. *V. rufescens*, aside from the type, is known from more southern latitudes (Southern district of Vanuatu, Lifou and New Caledonia), whereas *V. crobylos* is restricted to more northern districts of Vanuatu. This extrinsic information

casts some doubt on the separation of these speeies, however their morphologies are conclusive.

Vanniusoides Carvalho & Lorenzato, 1978

Vanniusoides Carvalho & Lorenzato, 1978: 128 (gen. nov.); Schuh, 1995: 39 (catalogue); Gorczyca, 1996:337, 340 (note); 1997: 520, 537 (description); Gorczyca & Konstantinov, 2001: 107-110 (description).

TYPE SPECIES. *Vannius brevis* Poppius, 1909, by original designation.

DIAGNOSIS. Body smooth; pallid with disruptive red eolouration; frons weakly surpassing eyes dorsally; pronotal collar moderately broad, laterally restricted; antennae longer than body; first antennal segment a little longer than head length (Fig. 3A,B); first antennal segment weakly arcuate, not compressed nor densely setate; pronotum (Fig. 3A,B) campanulate; posterior margin of pronotum bisinuate; mesoseutum exposed; peritreme anteriorly oriented, spout-like; metafemora narrow and elongate; tarsal claws with subapical tooth; endosoma (Fig. 18C) without lobal sclerites, with pair of arcuate basal sclerites; left paramere (Fig. 18A) strongly arcuate; female with spinose posterior wall (Fig. 19B,D).

DESCRIPTION. *Colouration*. Body (Fig. 3A,B) mostly stramineous, dorsum with disrupted red-orange markings. Antennae not banded. Labium: LI mostly red; LIII-IV stramineous. Thoracic pleura mostly red or fuscous-red. Tibiae and femora either mostly stramineous and eoneolorous or stramineous and banded (red). Hemelytral membrane clear. Abdomen mostly stramineous with red markings.

Texture. Dorsum smooth.

Vestiture. Dorsum with moderate distribution of simple, decumbent, elongatc setae.

Structure. Maeropterous (Fig. 3A,B); elongate. Head: vertex flat without longitudinal medial sulcus (Figs 3A,B); eyes enlarged, oceupying mueh of the lateral aspect of the head apically aeute or rounded; frons weakly expressed beyond eyes; mandibular plates enlarged, sometimes flattened, anteriorly direeted. Antennae: (Fig. 3A,B) significantly longer than body, thread-like; AI moderately swollen, weakly arcuatc, cylindrical in cross-seetion (not compressed), a little longer than head; AII-AIV elongate, thin. Labium extending to apiccs of metacoxae. Prontoum (Fig. 3A,B) transverse, campanulate; posterior margin bisinuate; pronotal collar flat, narrow, strongly narrowed laterally. Mesoscutum visible. Hemelytra (Fig. 3A,B) elongate, extending well beyond abdomen, depressed beyond euneal fraeture; cuneal fraeture weakly developed; euneus elongate, narrow. Proepisternum weakly depressed medially. Metathoraeic spiraele exposed, bounded by evaporative bodies. External efferent system: peritreme anteriorly oriented, tumid, spout-like. Legs elongate; metafemora elongate (Figs 3A,B), narrow, tapered distally. Tarsal elaws moderately areuate, eaeh with subapieal tooth. Male genitalia: parameres elongate, subequal in length; left paramere (Fig. 18A) with expanded sensory lobe; right paramere (Fig. 18B) elongate, sublinear, apex attenuated; phallotheea short; endosoma (Fig. 18C) either a membranous sae with a pair of small basal selerites or strongly sclerotised basal selerite with small terminal membranous sac, seeondary gonopore undifferentiated. Female genitalia: sclerotised rings (Fig. 19A,C) flattened, somewhat ovate, thin; ventral labiate plate widely separated; dorsal labiate plate mostly in one plane; posterior wall (Fig. 19B,D) mostly membranous, with thin bilateral inter-ramal sclerites; without inter-ramal lobes.

DISTRIBUTION. Northeastern Papua New Guinea, the Solomon Islands, Fiji Islands and Australia (north Queensland) (Fig. 17).

REMARKS. *Vanniusoides* does not have any eharacters that uniquely distinguish it, and is at present defined polythetieally. The male genitalia are somewhat simplified, with the endosoma (Fig. 18C) without lobal selerites, and eomposed of strap-like basal sclerites, with the secondary gonopore undifferentiated. In *V. melafrons*, the endosoma (Fig. 18C) is tube-like (basal selerites somewhat fused) and appears to be modified from the simple condition found in *V. clypeatus*, where the endosoma is a narrow membraneous sae supported by strap-like basal proeesses. This latter charaeter state is also found in *Vanniopsis crobylos*, and to some extent in *Vanniopsis howense*. The female genitalia are not suffieiently distinetive to separate *Vanniusoides* and *Vanniopsis*. These genera are best separated by external eharaeters. In *Vanniopsis*, the first antennal segment is eompressed and densely setate, charaeter states that do not oecur in *Vanniusoides*. Morcover, the vertex of the latter is not sulcatc, in comparison to most other genera of the *Vannius* complex (ineluding *Vanniopsis*), aside from *Austrovannius*.

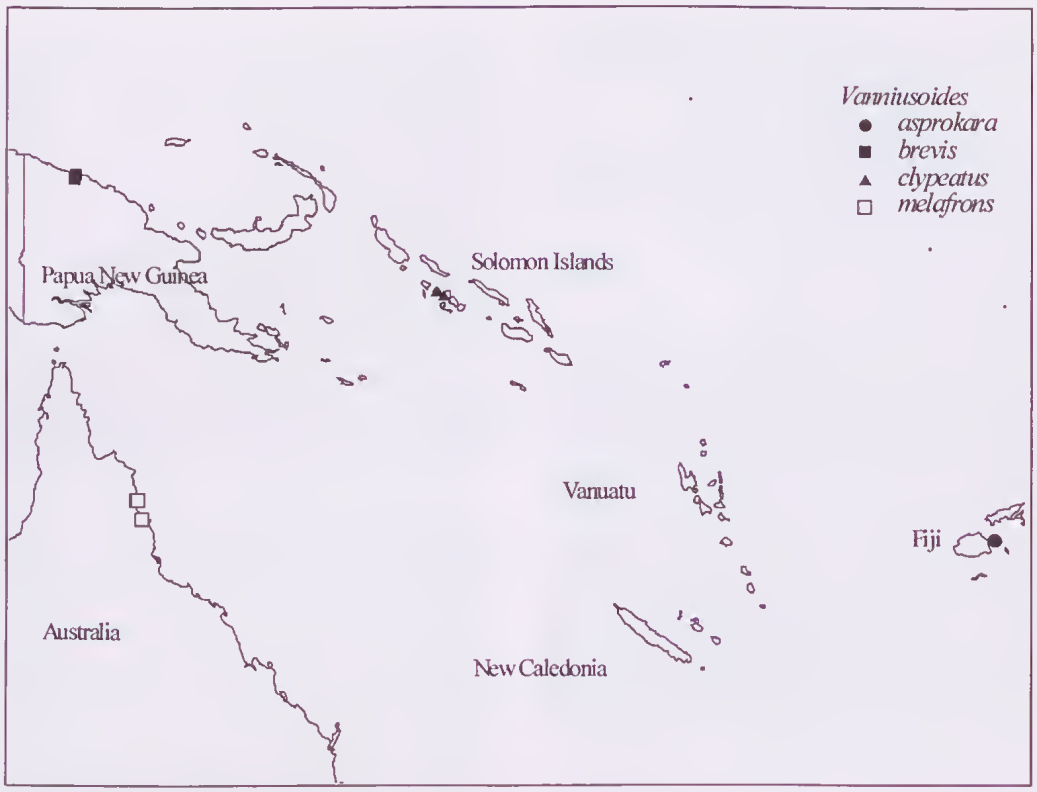

FIG. 17. Distribution map of *Vanniusoides*.

KEY TO THE SPECIES OF *VANNIUSOIDES*

1. Clypeus with distal tubercle . . . . . *brevis*
   Clypeus without tubercle 2
2. Frons and clypeus fuscous to fuscous-red; propleura fuscous to fuscous-red . . . . *melafrons* sp. nov.
   Head uniformly stramineous, at most with minor red highlighting; propleura fuscous to fuscous-red or with reddish longitudinal band 3
3. Lateral margins of pronotum with red markings (Fig. 3A); clypeus narrow and parallel sided, distally truncate; propleura stramineous . . . . . *asprokara* sp. nov.
   Lateral margins of pronotum entirely stramineous; clypeus distinctly broadened at base, distally rounded; propleura stramineous with transverse reddish band . . . . . *clypeatus*

Vanniusoides asprokara sp. nov. (Figs 3A, 17, 19A,B)

ETYMOLOGY. Greek *aspros* (= white) and *kara* (= head), in reference to the stramineous head of this species.

MATERIAL. FIJI. Holotype, ♀, Thawathi, Ovalau, [17°38'S 178°49'E], 600-800 ft. [183-244m], 16 July [19]38, EC Zimmerman (BPBM). Paratypes: ♀, Draiba Trail, Ovalau, [17°42'S 178°48'E], 600-800 ft. [183-244m], 9 July [19]38, EC Zimmerman (AM); ♀, nr. Vuma, Ovalau, [17°40'S 178°49'59"E], 700 ft. [213m], 14 July [19]38, EC Zimmerman (BPBM).

DIAGNOSIS. Head uniformly stramineous; pronotum and hemelytra with distinct pattern of red markings (Figs 3A,B); apex of clypeus truncate, not expanded, without distal tubercle; metafemora stramineous with subproximal, submedial and apical red bands; tibiae uniformly stramineous.

DESCRIPTION. *Colouration*. Body (Fig. 3A) mostly stramineous with disruptive red markings on dorsum. Head: mostly stramineous, sometimes areas adjacent to antennal insertions with reddish highlighting. Antennae: AI mostly red, sometimes stramineous-red; AII stramineous, sometimes with obscure red tinge; AIII-IV stramineous-brown. Pronotum mostly stramineous, with lateral margins and medioposterior region red; collar mostly stramineous, laterally red, rarely with medial red spot. Mesoscutum and scutellum mostly stramineous, with continuous medial red spot. Hemelytra stramineous with red markings; clavus

stramineous, with broad red longitudinal marking on anterior half medially; endocorium with two large medial red spots, subapex of embolium with narrow red marking; cuneus mostly stramineous with medial red spot. Legs mostly stramineous; coxae sometimes with red highlighting; femora stramineous with submedial and apical red banding; tibiae stramineous, sometimes with red stippling. Abdomen mostly stramineous, with lateral margins and subgenital regions red.

Structure. Habitus (Fig. 3A). Clypeus parallel-sided, apex truncate, without tubercles. Labium reaching metaeoxae. Female genitalia with selerotised rings (Fig. 19A) obscure, flattened, ovoid, thin, widely separated; ventral labiate plate widely separated; dorsal labiate plate undifferentiated; posterior wall (Fig. 19B) extremely membranous with bilateral inter-ramal sclerites in middle of membrane .

Males unknown.

Measurements. 3♀♀ BL 3.84-4.20, HW 0.61-0.65, IOD 0.24-0.25, HL 0.28-0.35, PL 0.34-0.37, PW 1.01-1.06, AII 1.90-2.08, LL 1.08-1.20.

DISTRIBUTION AND HABITAT. On Ovalau in the Fijian Islands (Fig. 17). The habitat is unknown.

REMARKS. *Vanniusoides asprokara* is distinguished from other species of *Vanniusoides* by the pattern of red markings on the dorsum (Fig. 3A); in partieular the red lateral margins of the pronotum are unique to this speeies. In addition, this species has the propleura uniformly stramineous and the metafemora have red bands. The female genitalia are also distinet (ef. Fig. 19D).

Vanniusoides melafrons sp. nov.
(Figs 3B, 17, 18, 19C,D)

ETYMOLOGY. Greek *melas* (= black) and Latin *frons* (= forehead) referring to the dark front of the head.

MATERIAL. QUEENSLAND: Holotype, ♂, Cape Tribulation, 16°07.3'S 145°26.3'E, 28 March 2000, RL Kitching eanopy fog (QM T108615). Paratypes ♀, Kuranda, [16°49'S 145°38'E], 13 March 1956, JL Gressitt (BPBM); ♀, Cooper Creek, 10 ml [16km] N of Daintree Riv[er], [16°08'S 145°27'E], 2 May 1970, GB Monteith (UQIC).

DIAGNOSIS. Frons and elypeus fuseous to fuscous-red; clypeus distally truneate, without tubcrele; pronotum and hemelytra with distinet red patterning; metafemora stramineous with subproximal, submedial and apieal red bands; tibiae with two submedial red bands; parameres

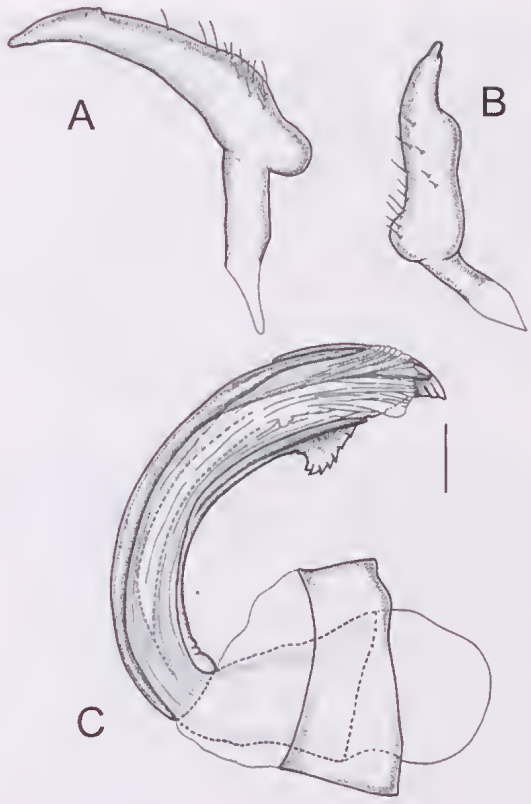

FIG. 18. *Vanniusoides melafrons*. A, left paramere; B, right paramere; C, aedeagus. Scale bar = 0.10mm.

(Figs 18A,B) elongate; endosoma (Fig. 18C) strongly selerotised with serrate apical flange.

DESCRIPTION. *Colouration*. Body mostly stramineous with disruptive red markings on dorsum (Fig. 3B). Head: vertex stramineous, remainder of head red to fuscous-red (Fig. 3B). Antennae: AI red; AII stramineous, sometimes with red highlighting; AIII-AIV stramineous to stramineous-brown. Pronotum mostly stramineous with pair of submedial caudal red spot (Fig. 3B). Thoracic pleura fuscous to fuscous red, sometimes metepisternum more red-brown. Mesoseutum and scutellum mostly stramineous with pair of sublateral red spots. Hemelytra mostly stramineous, with distinctive red patterning (Fig. 3B); clavus with inner margins and apiees red; endoeorium with broad red band adjacent to clavus, red spots on endoeorial angle, subapex of embolium and posteriad of R+M. Legs mostly stramineous; eoxae either mostly brown with apices

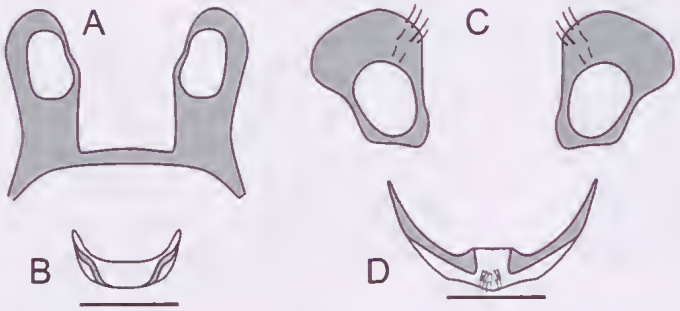

FIG. 19. Female genitalia. *Vanniusoides asprokara*. A, sclerotised rings; B, posterior wall; *Vanniusoides melafrons*; C, sclerotised rings; D, posterior wall. Scale bar = 0.25mm.

stramineous or more uniformly pale; meta femora stramineous with subproximal, submedial and apical red bands; tibiae with two submedial red bands. Abdomen mostly stramineous with lateral margins and subgenital regions red.

Structure. Habitus (Fig. 3B). Clypeus parallel-sided, apex truncate, without tubercles. Labium extending just beyond apices of metacoxae. Male genitalia: left paramere (Fig. 18A) elongate with expanded sensory lobe and acute apex; right paramere (Fig. 18B) elongate, abruptly constricted subapically, apex pointed; endosoma (Fig. 18C) tube-like, formed by pair of strongly sclerotised basal sclerites, one strap with terminal serrate flange, membranous sac terminal. Female genitalia: sclerotised rings (Fig. 19C) flattened, obscure, circular, thin, widely separated; ventral labiate plate widely separated with strong spinules; dorsal labiate plate basically flattened, spinose, simple, adhering to floor of genital chamber; posterior wall (Fig. 19D) thin, membranous with strong spinules mesially and bilateral inter-ramal sclerites dorsally.

Measurements. 1♂ (Holotype) BL 3.2, HW 0.61, IOD 0.17, HL 0.37, PL 0.40, PW 1.01, AII 1.74, LL 1.25; 2♀♀ BL 4.10-4.30, HW 0.60-0.62, IOD 0.17-0.19, HL 0.34-0.37, PL 0.33-0.34, PW 1.08, AII 1.76-1.80, LL 1.34-1.40.

DISTRIBUTION AND HABITAT. Rainforests of the wet tropics of northeast Queensland (Fig. 17).

REMARKS. The fuscous front of the head differentiates this species from *V. asprokara* and *V. clypeatus*, both of which have pale heads. Moreover, the hemelytra have more red markings (cf. Fig. 3A,B). The male genitalia of *V. melafrons* and *V. clypeatus* are the only species investigated to date, and their morphologies differ, with the former species having a tube-like endosoma (Fig. 18C).

Vanniusoides clypeatus
Gorczyca & Konstantinov, 2001
(Fig. 17)

Vanniusoides clypeatus Gorczyca & Konstantinov 2001: 108 (sp. nov.).

MATERIAL. SOLOMON ISLANDS: 1♂, New Georgia Island, Munda, 0-100m, XI-1980, N.L.H. Krauss coll. (BPBM).

REMARKS. This species is distinctive because of the highly autapomorphic condition of the clypeus and mandibular plates, which are both rounded apically. The male genitalia are identical to those illustrated by Gorczyca & Konstantinov (2001). These authors have provided a detailed description of the species and we have opted against providing a redescription.

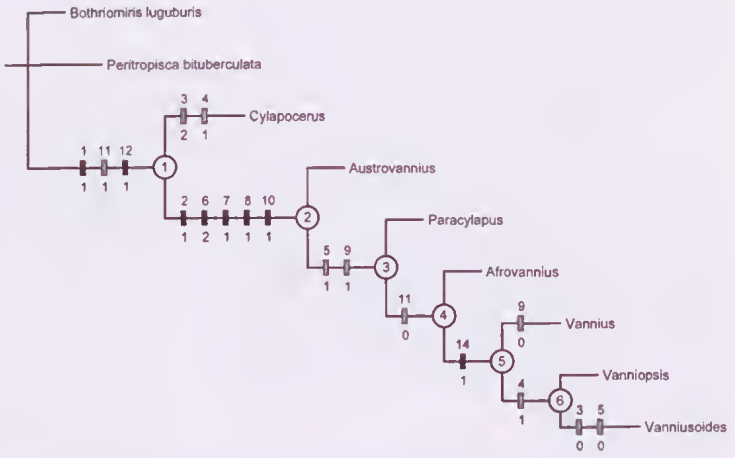

FIG. 20. Cladogram of genera of *Vannius* complex. Synapomorphies = black boxes; homoplasies = grey boxes. Superscript numerals = character number; subscript numerals = character state. Numerals in circles = node number. Length = 30 steps. Consistency index = 0.70. Retention index = 0.70.

TABLE 1. Characters and character states of the *Vannius* complex and outgroups.

1. Head orientation: horizontal (0); dorsoventral (1).
2. Frons and clypeus: bilobed (0); coplanar (1).
3. Vertex: without medial sulcus (0); with shallow sulcus (1); with deep sulcus (2).
4. Antennal segment I: shorter or subequal to head length (0); significantly longer than head length (1).
5. Antennal segment II: concolorous (0); banded (1).
6. Pronotal collar: absent (0); rounded and thin (1); flat and broad (2).
7. Dorsum commonly with disrupted red colouration: no (0); yes (1).
8. Metafemora: moderately elongate (0); greatly elongate (1).
9. Pretarsal claws: without subapical tooth (0); with subapical tooth (1).
10. Parempodia: setiform (0); spatulate (1).
11. Secondary gonopore: indistinguishable (0); well-sclerotised, with spinose aperture (1).
12. Endosoma: without basal sclerites (0); with basal sclerites (1).
13. Endosoma: without lobal sclerites (0); with lobal sclerites (1).
14. Basal sclerite: free from base of endosoma, not fused (0); extending to apex of endosoma, fused and somewhat bent (1).
15. Sclerotised rings: thin, not strongly bent, without projections from lateral and mesial margins (0); thick, somewhat strongly bent, with projections from lateral and mesial margins (1).
16. Ventral labiate plate: separated medially (0); joined on anterior margin (1).
17. Dorsal labiate plate: not expanded lateral of sclerotised rings (0); expanded lateral of sclerotised rings, lateral most margins scroll-like (1).
18. Inter-ramal sclerite: divided, structure formed of two thin sclerites (0); completely spanning base of first valvifer (1).
19. Inter-ramal lobes: absent (0); present (1).

PHYLOGENETICS

These results are based on an analysis of the six genera of the *Vannius* complex and three outgroups within the Cylapinae, including exemplars of the Bothriomirini (*Bothriomiris lugubris*), Fulviini (*Peritropisca bituberculata*) and Cylapini (*Cylapocerus*). The characters and character states are given in Table 1 and the data matrix in Table 2. A single cladogram of minimum length (30 steps) was obtained with a consistency index of 0.70 and a retention index of 0.67. The discussion of sister groupings is based on the synapomorphies shown in Fig. 20.

Node 1 – The Cylapini are defined in this analysis by the dorsoventral head (1-1), secondary gonopore sclerotised with a dentate aperture (11-1), and the endosoma with basal sclerites (12-1). Neither of these characters are exclusive to the Miridae, but are not found in the exemplars of the other recognised supragenerie groups of Cylapinae (Bothriomirini and Fulviini) that were examined. Some representatives of the Fulviini (e.g. Kelton, 1959) are known to possess basal sclerites, and this is not considered to be a reliable synapomorphy for the Cylapini, although the basal sclerites of the latter tribe are often strap-like. Further investigation is required to determine if the 'basal sclerites' character can be differentiated to identify additional synapomorphies. The secondary gonopore varies within the ingroup and this character is homoplasic in this analysis.

Node 2 – The *Vannius* complex is defined by the following synapomorphies: gular and the frons and the clypeus in the same plane (2-1); pronotal collar broad and flat (6-1); dorsum with disrupted colouration (7-1); metafemora greatly elongate (8-1); and, parempodia spatulate (10-1). The derived states of characters 7 and 8 are also found in other members of the Cylapinae, and require further investigation beyond the outgroups that were examined. The coplanar frons + clypeus is also deserving of more investigation, particularly for taxa such as *Cylapus* Say and its relatives, but is unlikely to be upheld as a synapomorphy for the *Vannius* complex. The spatulate parempodia remain the most conclusive synapomorphy for the *Vannius* complex, and is unknown for all other examined cylapines. As noted above, the condition also occurs in *Palaucoris*, a few taxa of Termatophylini (Deraeocorinae) and Phylinae, but these are undoubtedly independent derivations. The broad and flat pronotal collar is also considered to be a credible synapomorphy, as the pronotal collar in the Cylapini is at most narrow and more rounded.

Node 3 – In this analysis, *Austrovannius* is sister-taxon to the remainder of the *Vannius* complex. The latter subset is defined by the banded antennae (5-1) and tarsal claws with subapical teeth (9-1). Both of these characters exhibit homoplasy, with *Vannius* lacking subapical teeth (5-0) and *Vanniusoides* possessing concolorous antennae (9-0).

Node 4 – *Paracylapus* is the next most basal taxon of the *Vannius* complex. The remaining genera are united by a single homoplasic character; secondary gonopore indistinguishable (11-0).

Node 5 – *Afrovannius* is sister-taxon to the rest of the *Vannius* complex. *Vannius* + (*Vanniopsis* +

TABLE 2. Character matrix of three outgroups (*Bothriomiris lugubris*, *Peritropisca bituberculata* and *Cyalpocerus* sp.) and six genera of the *Vannius* complex against 19 characters. Missing data = ?

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bothriomiris lugubris	0	0	0	0	0	0	0	0	0	?	0	1	?	?	?	?	1	1	0
Peritropisca bituberculata	0	0	1	0	0	0	0	0	0	0	0	1	?	?	?	?	0	0	1
Cylapocerus	1	0	2	1	0	0	0	?	0	1	1	0	0	?	?	?	?	?	1
Afrovannius	1	1	1	0	1	1	1	1	1	0	1	0	0	?	?	?	?	?	2
Austrovannius	1	1	0	0	0	1	1	0	1	1	1	1	0	1	1	0	1	1	2
Paracylapus	1	1	1	0	1	1	1	1	1	1	1	0	0	?	?	?	?	?	2
Vanniopsis	1	1	1	1	1	1	1	1	1	0	1	0	?	0	0	1	0	0	2
Vannius	1	1	1	0	1	1	1	0	1	0	1	0	1	?	?	?	?	?	2
Vanniusoides	1	1	0	1	0	1	1	1	1	0	1	0	1	0	0	1	0	0	2

Vanniusoides) are a clade on the basis of one synapomorphy; basal sclerites extending to apex of endosoma (14-1). This represents the most supported in-group clade within the *Vannius* complex. These three Eastern Hemisphere genera are also saliently alike, and it is predicted that additional synapomorphies will be found for this clade.

Node 6 – *Vanniopsis* and *Vanniusoides* are united on the basis of a single homoplasic character; first antennal segment significantly longer than the head (4-1). In addition, these taxa also exhibit similar male genitalia, with the endosoma having basal sclerites and lacking lobal sclerites.

ACKNOWLEDGEMENTS

The following curators are thanked for their provision of specimens: Gordon Nishida (BPBM); Geoff Monteith (QM), Jan Forrest and Gordon Gross (SAMA); and, Margaret Schneider and Greg Daniels (UQIC). Roger Kitching (Griffith University) also provided material from north Queensland. Geoff Monteith is particularly thanked for providing much of the material and taking a special interest in collecting cylapines in wet rainforests of north Queensland and New Caledonia. His material has allowed for a broader understanding of Cylapinae systematics. Ian Hutton assisted with the collection of *Vanniopsis howense* from Lord Howe Island. The Lord Howe Island Board is thanked for allowing collecting on the island and access to their research facility. Rossana Silveira assisted with many aspects of the project, including the illustrations of the female genitalia. Gareth Carter assisted with the distribution maps. Matthew Bulbert took the habitus figures of Figure 3. Hannah Finlay inked the sketches of the male genitalia. Heloise Gibb provided the habitus illustrations. Sue Lindsay was responsible for the scanning electron microscopy. Chris Reid is particularly thanked for his support of our work, including collections of new material and reading of the manuscript. Dan Bickel and Winston Ponder also provided advice on the biogeography of the Australian region. The Australian Museum Trust is thanked for its support of biodiversity and taxonomic research. This work is partly funded by an allocation from the New South Wales State Biodiversity Strategy and the Australian Biological Resources Study.

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NEW RECORDS OF PALICID CRABS (CRUSTACEA: BRACHYURA: PALICIDAE) FROM AUSTRALIA

P. CASTRO AND P.J.F. DAVIE

Castro, P. & Davie, P. 2003 06 30: New records of palicid crabs (Crustacea: Brachyura, Palicidae) from Australia. *Memoirs of the Queensland Museum* 49(1): 153-157. Brisbane. ISSN 0079-8835.

Eight species of palicid crabs have been identified from Australia. *Parapalicus ambonensis, Paliculus kyusyuensis, Exopalicus maculatus* and a species close or identical to *Miropalicus vietnamensis* are recorded for the first time in Australia. There are also first records of *Neopalicus jukesii* from Western Australia and *Crossotonotus spinipes* from the Northern Territory and the Cocos (Keeling) Islands. Thirteen species of Palicidae are now known from Australian waters. ❐ *Palicid crabs, new species, Australia.*

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Little is known about the biology of palicid crabs. Most species are inhabitants of soft sediments in relatively deep water, while some are found in shallow water associated with coarse sediments near coral reefs or with rocky bottoms. All seem to ingest sediment particles. The taxonomy and biogeography of the 43 known species of Indo-west Pacific palicids has been reviewed by Castro (2000).

Castro (2000) recorded 9 palicid species from Australian waters. Material from several Australian museums adds four additional species, increasing the number of Australian species to 13. In addition to the 8 species listed here, 5 were previously recorded from Australia by Castro (2000): *Pseudopalicus investigatoris* (Alcock, 1900), *P. macromeles* Castro, 2000, *P. ohauensis* (Rathbun, 1906), *P. serripes* (Alcock & Anderson, 1895) and *Pleurophricus cristatipes* A. Milne Edwards, 1873.

Abbreviations used: AM, Australian Museum, Sydney; MMUS, MacLeay Museum, University of Sydney; QM, Queensland Museum, Brisbane; WAM, Western Australian Museum, Perth; CL, carapace length; CW carapace width.

Subfamily PALICINAE Bouvier, 1898

Parapalicus Moosa & Serène, 1981
Parapalicus ambonensis Moosa & Serène, 1981
(Fig. 1A)

Parapalicus ambonensis Moosa & Serène, 1981: 29, figs 2a, 3a, pl. 1, fig. D; Castro, 2000: 489, figs 16, 19a, 58.

MATERIAL. QM W16970, 1♀, off Mission Beach, NEQLD, Australia, 17°53' S, 146°51' E, 140-142m, 20.01.1986, CSIRO, R.V. 'Soela'.

REMARKS. This is the first record of the species in Australia. It has been collected from mostly muddy bottoms of the Andaman Sea coast of Thailand, Banda and Coral Seas and off the island of Futuna, southwestern Pacific Ocean (Castro, 2000). Bathymetric range: 80-440m.

Miropalicus Castro, 2000
Miropalicus cf. **vietnamensis** (Zarenkov, 1968)
(Fig. 1B)

Palicus vietnamensis Zarenkov, 1968: 762, fig. 2A-F.
Miropalicus vietnamensis; Castro, 2000: 522-525, figs 29, 30a, 59, 60f (full synonymy and references).

MATERIAL. QMW25170. Incomplete specimen, North West Shelf, Western Australia, 19°59.1'S 117°49.0'E, beam trawl, 43m, CSIRO, RV *Soela*, stn 3D1BT, 25 June 1983.

REMARKS. The Australian specimen consists of only the anterior border of the carapace of a very small, most probably juvenile, specimen (distance between outer anterior lobes of 0.2 mm). The two orbits, the right supraorbital and suborbital borders and the right basal antennal segment were present. The pterygostomial lobe was missing on both sides. Characteristic of *Miropalicus* are the wide orbits, large eyes with dorsoventrally flattened cornea, very short supraorbital lobes and relatively short suborbital lobes, long and conspicuous postorbital angles with pointed tip directed outward, and a rectangular, slender basal antennal segment that lacks a distal expansion. Unlike the only species so far included in the genus, *M. vietnamensis*, the shallow supraorbital lobes are very wide and have a straight edge, not narrow with rounded tips (Castro, 2000: fig. 22a). The suborbital border

consists of a wide, oblique inner lobe unlike the slightly triangular lobe of *M. vietnamensis* (Castro, 2000: fig. 22b) and a narrow, slightly pointed outer lobe that is similar to that of *M. vietnamensis*. It is possible, however, that the simpler arrangement of both supraorbital and suborbital lobes is only a characteristic of juveniles. There are three small frontal lobes instead of the two in *M. vietnamensis*, a rare situation observed in other palicids and that perhaps results from damage and subsequent regeneration.

The Australian specimen was collected from 43m depth, whereas *M. vietnamensis* is known from 239-647m from the South China Sea to the Loyalty Islands, southern Coral Sea (Castro, 2000).

Paliculus Castro, 2000

Paliculus kyusyuensis (Yokoya, 1933) (Fig. 1C)

Palicus kyusyuensis Yokoya, 1933: 206, 217, fig. 70.
Paliculus kyusyuensis; Castro, 2000: 527-530, figs 30b, 31, 56 (full synonymy and references).

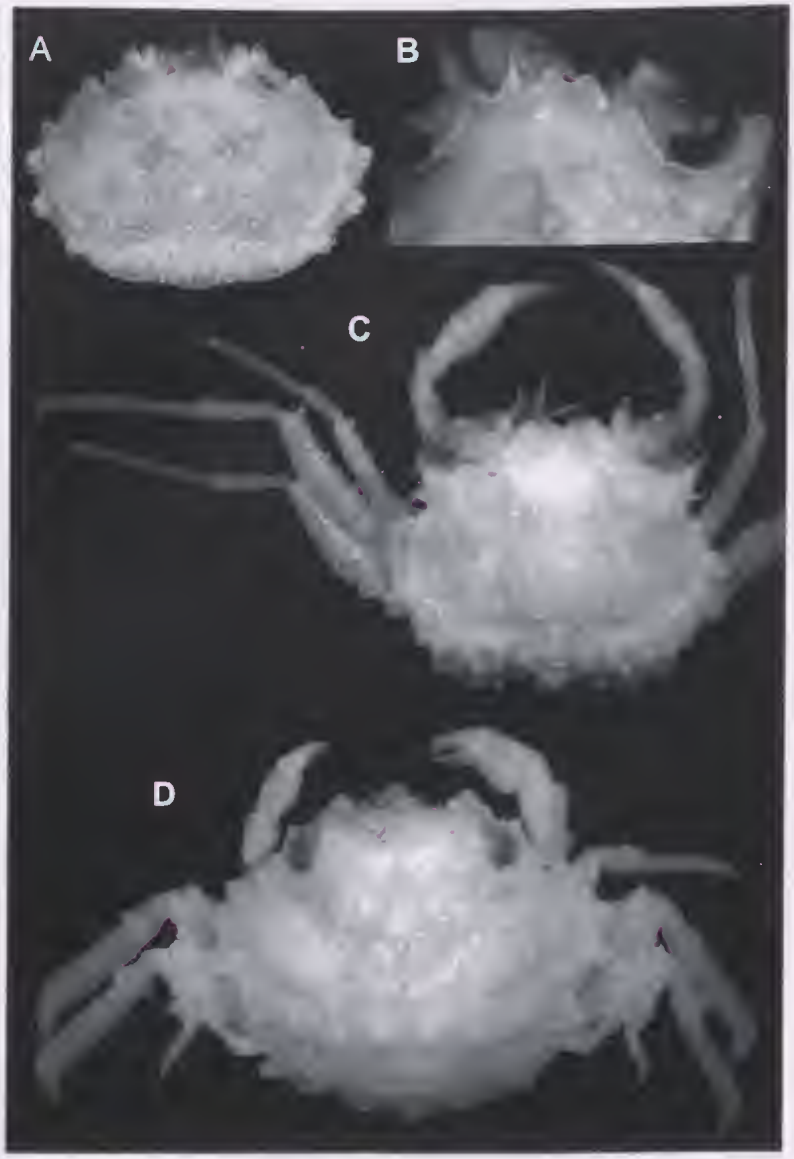

FIG. 1. A, *Parapalicus ambonensis* Moosa & Serène, 1981, ♀ (QM W16970); B, *Miropalicus* cf. *vietnamensis* (Zarenkov, 1968), incomplete specimen (QMW25170); C, *Paliculus kyusyuensis* (Yokoya, 1933), ♀ (QMW15415); D, *Exopalicus maculatus* (Edmondson, 1930), ♂ (QMW25171).

MATERIAL. QMW15417, 3♀, 1 juv. ♀, off Great Barrier Reef, Queensland, 17°21.77'S 146°48.52'E, epibenthic sledge, 296-302m, Cidaris I, stn 42-2, FRV *Franklin*, 15.05.1986; QMW15418, 8♀, juv. ♀ (same data as W15417); QMW15415, ♀, off Great Barrier Reef, 17°34.58'S 146°53.21'E, epibenthic sledge, 458-500m, Cidaris I, stn 43-2, FRV *Franklin*, 15.05.1986; QMW15416, ♀, off Great Barrier Reef, 17°55.38'S 147°00.96'E, beam trawl, 295-309m, Cidaris I, stn 46-3, FRV *Franklin*, 16.05.1986.

REMARKS. The conspicuous, salient tubercles along the posterior border of the carapace show noticeable differences in size and shape, varying from short and broad to narrow and more acute. Dorsally the carapace has short, rounded tubercles, as in specimens studied by Castro (2000). These tubercles, however, were not shown in the illustration (Castro, 2000: fig. 23a).

The species is known from sandy bottoms at depths of 30-710m in relatively few locations in

the Indian Ocean (Madagascar) and from Japan to Wallis Island in the southwestern Pacific (Castro, 2000). This is the first record from Australia.

Exopalicus Castro, 2000
Exopalicus maculatus (Edmondson, 1930)
(Figs 1D, 2)

Palicus maculatus Edmondson, 1930: 15, figs 6a-g, pl. 1, fig. C.
Exopalicus maculatus; Castro, 2000: 546-548, figs 37d, 38, 56, 61b (full synonymy and references).

MATERIAL. QMW25171, ♂, Lady Elliott I., Bunker Group, Queensland, 24°07'S 152°43'E, coral reef near lighthouse, night dive, P. Davie & D. Potter, 14 Aug. 1985.

REMARKS. The presence of *Exopalicus maculatus* in eastern Australia confirms its wide distribution, having been known only from the Hawaiian and Marshall islands in the Pacific and Réunion in the western Indian Ocean (Castro, 2000). It has been collected in Guam (Castro, unpubl. data). As in most of the material from Hawaii and Réunion, the Queensland specimen was collected from a hard substrate in shallow water at night.

The live Australian specimen showed two large pairs of orange spots on a cream to light-yellow carapace (Fig. 2). There were irregular, red-brown markings along the anterior and posterior borders of the carapace. The legs were banded red-brown.

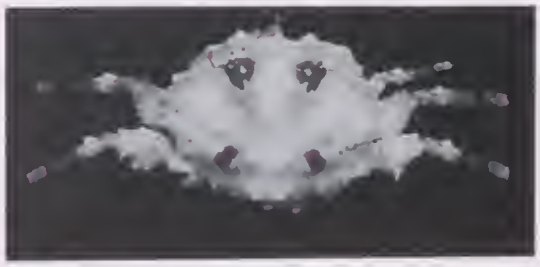

FIG. 2. *Exopalicus maculatus* (Edmondson, 1930), ♂ (QMW25171) showing pattern of live colouration.

Neopalicus Moosa & Serène, 1981
Neopalicus jukesii (White, 1847)

Cymopolia jukesii White, 1847: 338, pl. 2, fig. 1.
Neopalicus jukesii; Castro, 2000: 554-558 , figs 39b, 40b-c, 41c, 49, 61c (full synonymy and references).

MATERIAL. North West Shelf, Western Australia, CSIRO, RV *Soela* (64 stations between 19°03.0'S, 119°02.4'E and 20°01.2'S, 116°57.6'E, 36-82m depth, epibenthic sledge or beam trawl, from 8.12.1982 to 30.10.1983): QMW25123, 2 juv. ♀; QMW25134, ♂; QMW25110, 2♀; QMW25126, ♂; QMW25144, 2♂; QMW25138, juv. ♀; QMW25139, 2♂; QMW25116, ♂; QMW25146, ♂; QMW25115, ♀; QMW25124, juv. ♀; QMW25133, ♂; QMW25127, ♀; QMW25156, 2♀; QMW25160, unsexed juv.; QMW25125, ♀; QMW25154, 2♀; QMW25132, ♂; QMW25166, ♀; QMW25129, juv. ♀; QMW25155, 2 juv. ♀; QMW25162, ♂; QMW25111, ♂ ♀; QMW25147, ♂ incomplete specimen; QMW25114, ♂ ♀; QMW25117, 7♂ 3♀ juv. ♀; QMW25141, ♂ 2 unsexed juv.; QMW25135, juv. ♀; QMW25140, ♀; QMW25131, juv. ♀; QMW25106, ♂ 2♀; QMW25158, ♂ 2♀; QMW25145, ♂; QMW25163, ♂ 3 juv.; QMW25120, juv. ♀; QMW25130, juv. ♀; QMW25157, 3♀ juv. ♀ 2 unsexed juv.; QMW25159, ♂ 2♀; QMW25148, ♂ 5 unsexed juv., 2 incomplete specimens; QMW25165, juv. ♂ 2♀; QMW25152, damaged specimen; QMW25167, 2♀; QMW25128, 3♀; QMW25108, 2♂ 3♀ 5 juv. ♀; QMW25164, ♂ 2 juv.; QMW25161, ♂ 2 juv. ♀ 15 unsexed juv.; QMW25118, ♀; QMW25168, 2♂ 2♀; QMW25153, 2♂ juv. ♀; QMW25169, 5♀; QMW25109, ♀; QMW25112, ♂ juv. ♀; QMW25119, 10♂ 26♀ 3 juv. ♀; QMW25151, 4♂ ♀ juv. ♀ 32 unsexed juv.; QMW25149, ♂ 3 juv. ♀ 6 unsexed juv., 2 damaged specimens; QMW25107, 4♂ 3♀ juv. ♀; QMW25137, 2 juv. ♀ 3 unsexed juv., 2 incomplete specimens; QMW25143, 2♂ juv. ♀; QMW25122, ♀; QMW25121, 16♂ 5♀ 4 juv. ♀; QMW25136, 7♂ ♀ 4 juv. ♀ 3 incomplete specimens; QMW25142, 3 unsexed juv.; QMW25113, ♂ ♀ juv. ♀; QM25150, ♀ juv. ♂ juv. ♀ damaged specimen. WAM-C27188, ♀ Dampier Archipelago, 1.4 miles ESE of Tish Point, Rosemary I., 20°30.48'S 116°36.53'E, rake-box dredge, 9-10m, sandy mud, 26.07.1999; QMW17431, 2♀, Gulf of Carpentaria, 15°57.6'S 138°41.8'E, beam trawl, 25m, FRV *Southern Surveyor*, stn 94, 11.12.1991; AMP10524, ♂, Hayman I., Whitsunday Group, Queensland, 20°03'S 148°53'E, 9m, F.A. McNeill, Jan. 1934; AMP19525, ♂ 2♀, Whitsunday Group, Black I., near Langford, Nov. 1969.

REMARKS. The large number of juveniles collected (as small as CL 0.18mm, CW 0.27mm) permits their description for the first time. Anterior lobes are more salient than in the larger individuals. Anterolateral teeth are similarly more pointed and salient, the most anterior ones being the largest; the third and most posterior teeth are smallest and are absent in the smallest individuals. The carapace is nearly smooth.

N. jukesii ranges across the Indian Ocean to the western Pacific (southern Japan to the Coral Sea) in mostly coarse sand at depths of 10-146m.

Palicoides Moosa & Serène, 1981
Palicoides whitei (Miers, 1884)

Cymopolia whitei Miers, 1884: 551, pl. 49, figs C, c.
Palicoides whitei; Castro, 2000: 565-568, figs 42b, 43b-c, 50, 61c (synonymy and references).

MATERIAL. MMUS-C2139, ♂, Darnley I., Queensland, 9°35'S 143°46'E, W.J. MacLeay, HMS Chevert, 7-8.08.1875; QMW9896, juv. ♀, 15km NW Lizard I., Queensland, 14°35.3'S 145°23'E, 27m, mud and shell substrate, Commonwealth Northern Prawn Survey, stn 1B/14, FV *Markwell Explorer*, Sept. 1979.

REMARKS. The species is known across the Indian Ocean to the western Pacific (southern Japan to the Coral Sea) (Castro, 2000). It inhabits coarse sand at depths of 7-70m.

Subfamily CROSSOTONOTINAE Moosa & Serène, 1981

Crossotonotus A. Milne Edwards, 1873

Crossotonotus compressipes A. Milne Edwards, 1873

Crossotonotus compressipes A. Milne Edwards, 1873: 259; Castro, 2000: 571-574, figs 44, 51 (full synonymy and references).

MATERIAL. MMUS-C2138, ♂, Darnley I., Queensland, 9°35'S 143°46'E, W.J. MacLeay, H.M.S. *Chevert*, 7-8.08.1875; MMUS-C2137, ♀ (data as for MMUS-C2138); QMW12488, juv. ♀, Dugong I., Torres Strait, 10°31'S 143°04'E, reef flat, low tide, Queensland Fisheries Service, 17.07.1974.

REMARKS. The dorsal surface of the female (QMW12488: CL 8.6mm, CW 9.4mm), although preserved for almost 26 years showed a dark-brown, irregular pattern on a light background.

C. compressipes, although rarely collected, is known from southern Japan to Samoa (Castro, 2000). It appears to be restricted to hard bottoms in shallow water.

Crossotonotus spinipes (De Man, 1888)

Pleurophricus spinipes De Man, 1888: 344, pl. 15, figs 1, 1a-c.
Crossotonotus spinipes; Castro, 2000: 574-578, figs 45, 46, 51, 61f (full synonymy and references).
Crossotonotus brevimanus; Morgan, 1992: 47.
Manella brevimana; Springthorpe & Lowry, 1994: 94.

MATERIAL. WAM-C19675, ♂, juv. ♂, SW end of Horsburgh I., Cocos (Keeling) Islands, to 30m, G.J. Morgan, 16.02.1989; WAM-C197573, juv. ♀, Cocos (Keeling) Islands, C.W. Bryce & F.E. Wells, 17.02.1989; WAM-C20595, ♂ juv. ♀, SW of Descartes I., Kimberley region, Western Australia, coral reef, G.J. Morgan, KIRE 1991, stn 22, 19.08.1991; QMW24154, juv. ♀, Gove Peninsula, Northern Territory, 12°10'S 136°50'E, N. Coleman, Feb. 1993; AM-P19434, juv. ♀, Mandora Point, Darwin, Northern Territory, 12°27'S 130°50'E, under rock at low tide, N. Coleman, 23.11.1972; QMW22451, juv. ♀, NE end of East Herald Cay, Coringa-Herald Nature Reserve, Queensland, 16°56'S 149°11'E, lagoon, 24m, Royal Geographic Society of Queensland Herald Cay Expedition, P. Davie & M. Preker, 27.06.1997; QMW25172, juv. ♂, Masthead I., Queensland, 23°32'S 151°44'E, pontoon, night dive, 9m, P. Davie & D. Potter, 11.02.1986; QMW1505, ♂, Mud I., Moreton Bay, Queensland, 23°32'S 150°51'E, V.F. Collin, 16.07.1942; QMW21895, juv. ♀, Lamont Reef, Capricorn Group, 23°36'S 152°03'E, 10m, N. Coleman, Sept. 1992.

REMARKS. The carapace of a very large male (QM1505: CL 27.6mm, CW 33.8mm) was atypical for the species. The anterior lobes were not bent upward and the tips of the anterolateral teeth were less pointed than is usual.

The species is widely distributed in the Indo-west Pacific except the southeastern Pacific (Castro, 2000). It is restricted to hard bottoms and known from the intertidal to 146m.

ACKNOWLEDGEMENTS

We are most grateful to P. Berents and S. Ayong (AM), J. Short (QM), D. Jones and M. Hewitt (WAM) and S. Norrington (MMUS) for their assistance in providing us with the material.

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NEW SPECIES OF *CHLAMYDOPSIS* (HISTERIDAE: CHLAMYDOPSINAE), WITH A REVIEW AND PHYLOGENETIC ANALYSIS OF ALL KNOWN SPECIES

MICHAEL S. CATERINO

Caterino, M.S. 2003 06 30: New species of *Chlamydopsis* (Histeridae: Chlamydopsinae), with a review and phylogenetic analysis of all known species. *Memoirs of the Queensland Museum* **49**(1): 159-235. Brisbane. ISSN 0079-8835.

Forty new species of *Chlamydopsis* are described and the 29 previously described species are reviewed. One of the new species is the second known New Guinean *Chlamydopsis*. The remainder are Australian, with the highest diversity from Queensland. Six species groups are proposed and three species are left unplaced. A phylogenetic analysis of adult morphology provides support for several of these groups, and offers clues to the placement of the enigmatic species. This study revealed numerous species to be sexually dimorphic. The cladistic analysis indicates that some of these dimorphisms have arisen independently in several lineages. This study synonymises *C. excavata* Lea and *C. puncticollis* Oke with *C. reticulata* Lea, and *C. atra* Lea with *C. variolosa* Lea. The following new species are described: *C. rana* sp. nov., *C. antennata* sp. nov., *C. trichonota* sp. nov., *C. dimorpha* sp. nov., *C. monteithi* sp. nov., *C. setifera* sp. nov., *C. lawrencei* sp. nov., *C. convergens* sp. nov., *C. coronis* sp. nov., *C. erupta* sp. nov., *C. transversa* sp. nov., *C. kununurra* sp. nov., *C. acutricha* sp. nov., *C. myrmecophila* sp. nov., *C. mallee* sp. nov., *C. pecki* sp. nov., *C. degallieri* sp. nov., *C. jayawijaya* sp. nov., *C. lucifer* sp. nov., *C. bataviae* sp. nov., *C. burnetta* sp. nov., *C. zborowskii* sp. nov., *C. pluriseta* sp. nov., *C. contorta* sp. nov., *C. pilosipes* sp. nov., *C. nielseni* sp. nov., *C. australis* sp. nov., *C. lepida* sp. nov., *C. convexa* sp. nov., *C. dispersa* sp. nov., *C. weiri* sp. nov., *C. crowcrofti* sp. nov., *C. macmillani* sp. nov., *C. nullarbor* sp. nov., *C. rotunda* sp. nov., *C. carinota* sp. nov., *C. storeyi* sp. nov., *C. matthewsi* sp. nov., *C. mareeba* sp. nov., and *C. parallelus* sp. nov. ❐ *Coleoptera, Histeridae, Chlamydopsis, myrmecophily, tactile mimicry.*

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The Chlamydopsinae is a remarkable group of histerid beetles. They apparently all live in the colonies of social insects, mainly ants, and exhibit a tremendous diversity of morphological specialisations for this lifestyle. The group's distribution is centred in Australia, although several lineages have spread and diversified throughout southeastern Asia, reaching India in the west, Japan to the north, and Fiji to the east (Caterino, 2000; Dégallier, 1984; Nishikawa, 1995, 1996). Until recently the group has received little study. However, recent collecting efforts, particularly those incorporating flight interception traps, have revealed a wealth of unrecognised diversity. Here 40 new species are described, the taxonomic status of previously described species is reviewed, and the phylogenetic relationships among all known *Chlamydopsis* Westwood, are investigated. A recently discovered new species of *Chlamydopsis* from New Caledonia is not described here but is included in the phylogenetic analysis.

Something of a quandry is faced in presenting the species. While one of the goals of the phylogenetic analysis is to provide some framework for an intrageneric classification, it is clear from the outset that complete phylogenetic resolution will not be obtained from existing data. Too many species are known from only a single sex or even a single specimen, and many important data are therefore missing. For the purposes of facilitating identification and placement of additional material, a series of species groups is established. Some of these appear likely to be monophyletic, whereas putative synapomorphies of others are clearly weak. The phylogenetic analysis presented below will provide some preliminary indications of the relative values of morphological characters in the group. However, establishing a solidly phylogenetic classification will require much additional material and study.

CONVENTIONS

All species accounts include diagnoses and type data. For groups of closely related species, generally only one is fully described, with the remainder diagnosed from the first. In each treatment of a previously described species type locality, type repository, whether or not the type has been examined by the author (where it has

been, label data are quoted), and additional records, with either a repository or literature reference for each record, are presented. Nontype records are listed by source to distinguish specimen records from unverified literature records. Host ant names are as given by original sources. See Table 1 for equivalents in current formicid nomenclature.

A number of body dimensions and proportions are useful for species recognition. Following histerid conventions, total body length (L) is measured from the anterior margin of the pronotum to the posterior margin of the elytra, while width (W) is taken at the widest point, invariably near the elytral humeri. Measurements were made of the holotype where possible, are grouped at the beginning of each description (or diagnosis if no description is presented) to facilitate comparisons, and are abbreviated as follows: L (mm – dorsal length along midline); W (mm – width across humeri); E/PnL (ratio – elytral length/pronotal length); E/PnW (ratio – elytral width/pronotal width); Pn W/L (ratio – pronotum width/length); E L/W (ratio – elytra length/width); Pr/Py (ratio – Propygidium length/pygidium length); Sterna – pro, meso, meta (mm – lengths along midline); Tibiae – pro,meso,meta (mm – straight line length from base to apex, ignoring curvature). Some measurements are missing due to inaccessibility of material or relevant body parts. Accepted terminology is lacking for many unique chlamydopsine features. Terms adopted in this paper seem largely self-explanatory with one exception. The depression surrounding the prothoracic leg is margined by a stria originating at the apex of the prosternal keel, curving obliquely toward the anterolateral prosternal corner, thence curving variously toward the posterolateral prosternal corner. Regardless significant variation in exact orientation and degree of impression (which may render it more carinalike than striate) this is termed the circumcoxal stria.

Repositories are abbreviated as follows: Australian Museum, Sydney (AMS); Australian National Insect Collection, Canberra (ANIC); Henry and Anne Howden Collection (HAHC); Queensland Department of Primary Industries, Mareeba (DPIM); Museum of Comparative Zoology, Harvard University (MCZ); Michael Caterino Collection (MSCC); Museum Victoria, Melbourne (MVM); The Natural History Museum, London (NHM); Queensland Museum, Brisbane (QMB); South Australian Museum, Adelaide (SAM); Staatliches Museum für Naturkunde, Stuttgart (SMNS); United States National Museum, Washington (USNM); Western Australian Museum, Perth (WAM). 'QMT' registration numbers are given for holotypes deposited in QMB.

TABLE 1. Several host names have changed since their chlamydopsine association was first reported. Although some ambiguities have been encountered, the following equivalences appear valid (following Shattuck & Barnett, 2001). Multiple valid names indicate that the original species has been split into several. Those potentially sympatric with the beetle(s) are listed. Names not listed apparently remain valid as originally given.

Published Name	Valid Current Name
Chalcoponera metallica	*Rhytidoponera metallica* (Smith)
Ectatomma metallicum	*Rhytidoponera metallica* (Smith)
Rhytidoponera convexa var. *violacea*	*R. violacea* (Forel)
Euponera lutea	*Pachycondyla lutea* (Mayr)
Iridomyrmex detectus	*I. purpureus* (Smith), *I. sanguineus* Forel, or *I. viridiaeneus* Viehmeyer
Aphaenogaster longiceps	*A. l. longiceps* (Smith)
Notoncus foreli	*N. ectatommoides* (Forel)
Meranoplus hirsutus	*M. minor* Forel [formerly *M. hirsutus minor*]

Within material lists, holotype data are quoted exactly but for other material states and various geographical features are abbreviated as follows: Australian Capital Territory (ACT); Queensland (Qld); Northeastern Queensland (NEQ); Southeastern Queensland (SEQ); New South Wales (NSW); Victoria (Vic); South Australia (SA); Western Australia (WA); Northern Territory (NT); rainforest (RF). Collectors are abbreviated as follows: J. Brown (JB); A. Calder (AC); D.J. Cook (DC); S. De Faveri (SD); K. Halfpapp (KH); J. Hasenpusch (JH); H. Janetzki (HJ); J.F. Lawrence (JL); L. Miller (LM); G.B. Monteith (GM); E.S. Nielsen (EN); E. Schmidt (ES); S. Shattuck (SS); R. Storey (RS); G.I. Thompson (GT); L. Umback (LU); M.S. Upton (MU); T. Weir (TW); P. Zborowski (PZ). Collection methods abbreviated as: Flight Interception trap (FIT); Malaise trap (MT); pitfall trap (PT). Collection dates are given as day.month.year, with month represented by lower case roman numerals (e.g., 1.vi.2002).

Chlamydopsis Westwood, 1869

Chlamydopsis Westwood, 1869: 317.
Byzenia King, 1869: 74 (type species: *Byzenia formicicola* King); Blackburn, 1891: 92.

TYPE SPECIES. *Chlamydopsis striatella* Westwood, 1869: 318; designated by Lewis, 1903: 428.

REMARKS. Species of *Chlamydopsis* are very diverse in morphology, and the genus cannot be defined at present by any definite synapomorphies. It may well prove to be paraphyletic with respect to at least one or two other genera. The species currently contained in *Chlamydopsis* all share a visible scutellum and an upturned anterior pronotal margin, at least above the antennal cavities, if not along the entire margin. None are entirely flattened dorsally (like *Ectatommiphila* Lea) and none have the strikingly elongate trichome setae seen in *Eucurtia* Mjöberg.

STRIATIPENNIS GROUP

The *striatipennis* group is founded primarily on trichome morphology. All share a well developed humeral trichome in which the outer and upper surface are continuously rounded, with the trichome open only mesally and along the lower anterior edge. The humeri are variously enlarged, often with the anterior corners broad and angular, apparently hollow within (the lateral surface being somewhat translucent), with a very short, inconspicuous anterior superficial stria, and lined along the inner, upper edge with a single longitudinal or oblique row of setae, which extends to near the anterior elytral margin. A protuberance arises from the elytral disk beneath the anteromesal corner of the trichome, which meets the dorsal fringe, or projects above it forming an erect, rounded lamina (Figs 1A-G, 28I). Generally a separate 'whorl' of setae can also be seen within the mesal opening of the trichome, just beneath the longitudinal fringe. The anterior prosternal margin is striate but ungrooved. The metatibiae are elongate and/or widened in many. The central portion of the anterior pronotal margin is usually separated by a notch from the anterolateral portions, with the notch continued behind the lateral portion by a stria or groove. The species *C. rana* sp. nov., *C. antennata* sp. nov., and *C. trichonota* sp. nov. are placed here somewhat tentatively, based on trichome structure. However, the prosternal marginal stria of these three is well impressed, and appears more groovelike than in the rest of the group. Whatever their relationships to the group, these three are all easily recognised as the only *Chlamydopsis* with lateral pronotal trichomes (Fig. 1E-G)

Chlamydopsis striatipennis Lea, 1919 (Figs 1A, 2A, 3, 28A, 29I)

Chlamydopsis striatipennis Lea, 1919: 177; Type locality: Vic: Lorne; repository: SAM; not examined.

RECORDS. NHM: Vic: Warburton, Fern Tree Gully. Lea (1925): Vic: Lakes Entrance, Oct., 'small black *Iridomyrmex*'; Vic: Beaconsfield, with *Ectatomma metallicum*. Oke (1923): Whittlesea; Warburton; Ferntree Gully; Belgrave; Emerald [all Vic]. ANIC: ACT: 35.19S 148.51E, Wombat Ck., 6km NE of Piccadilly Circus, 750m, i.1985; NSW: Mt Keira, Wollongong, ii.1981; NSW: Lorien W.R. 3km N Lansdowne/Taree, 22.xi.1987, ex r/f margin, wet sclr. forest FIT. DPIM: NSW: 3km N. Lansdowne via Taree, 25.1.1987, MT, rainforest margin. WAM: NSW: Wollongong, 1938.

DIAGNOSIS. L: 2.62; W: 0.87; E/Pn L: 2.0; E/Pn W: 1.62; Pn W/L: 1.50; E L/W: 0.82; Pr/Py: 1.18; Sterna: 0.69, 0.19, 0.93; Tibiae: 1.18, 1.25, 1.62. *Chlamydopsis striatipennis* appears to comprise one of the more distinctive, temperate offshoots of a varied complex of populations centred in the more tropical parts of eastern Australia. Thus far samples have not been sufficient to fully resolve species limits within this complex, though certainly more than one species is present. The populations which constitute *C. striatipennis* s. str. have the humeri strongly angular (produced laterally almost perpendicular to the pronotal margin), and have the elytra setose mainly on the anterior surface of the trichome and along the apical margin. They are also slightly larger in body size than average for the complex (among examined samples). However, humeral shape and pilosity vary tremendously across this complex, and it might eventually be desirable to define the species more broadly.

REMARKS. In addition to the records presented above (pertaining solely to *C. striatipennis* s. str.) specimens considered members of the '*striatipennis* complex' have been collected throughout Queensland, as far north as 12°S. Specimens from southeastern Queensland (27°20'S, 152°48'E, Stony Ck) are particularly close to 'typical' *striatipennis*. At the same time a few additional specimens from Vic (Bonang, Warburton) and NSW (Lansdowne; Wilson River Reserve) do not conform to the strict definition of *C. striatipennis*, as recognised here. A particularly distinctive form is known from several upper elevation localities (>1100m) in the vicinity of the Hugh Nelson Range (Qld: 17°27'S, 145°29'E). However, even among the few localities represented, there is variation that should be better represented before an additional

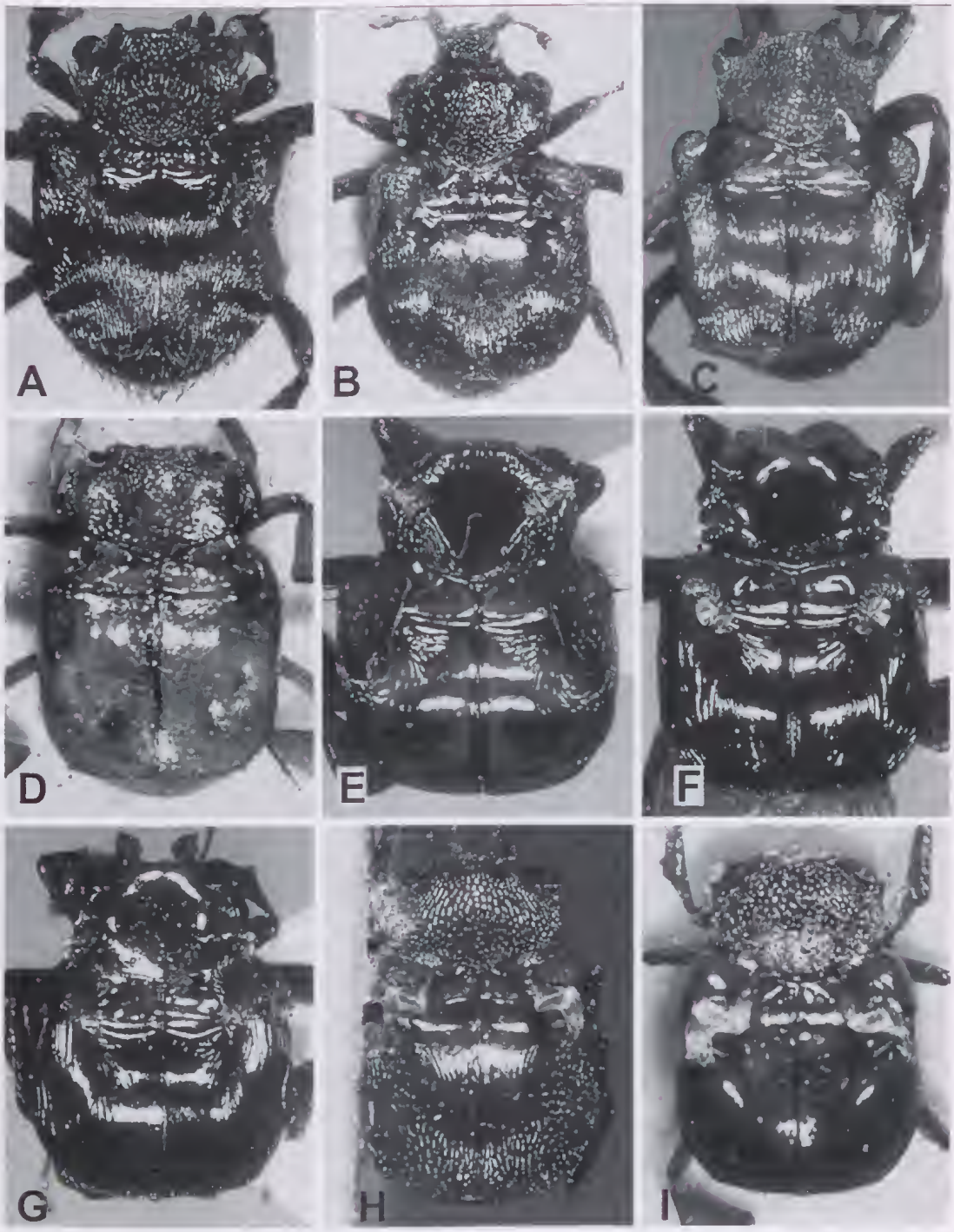

FIG. 1. Dorsal views of *Chlamydopsis* spp. A, *C. striatipennis*. B, *C. leai*. C, *C. compressipes*. D, *C. pallida*. E, *C. rana*. F, *C. antennata*. G, *C. trichonota*. H, *C. reticulata* (♂). I, *C. reticulata* (♀).

species is described. It is also possible that some of the remaining named species in this species group are derived from within the complex, particularly *C. leai* and *C. compressipes*.

Chlamydopsis leai Oke, 1923
(Figs 1B, 2B, 3)

Chlamydopsis leai Oke, 1923: 155; Lectotype ♀, hereby designated: Belgrave, Vic., 13.12.1920, C. Oke/ *Chlamydopsis leai* Oke Type/ Presented by C.G. Oke/ 895 Type, MVM. Paralectotype: Belgrave, Vic., July 1921, C.Oke 2.7.21/ *Chlamydopsis leai*, Oke. Co-Type/ 896 Paratype; in MVM; examined, 2000.

DIAGNOSIS. This species is a not-very-distinctive member of the *striatipennis* complex. The most distinctive character is its fairly broad, arcuate meso- and metatibiae (shared with *C. compressipes*, below). The upper inner edge of the trichome is slightly more oblique than typical, incising the humeral elevation posteriorly, although this is true of *C. striatipennis* s. str. as well. The species needs to be included in any broader study of variation in this complex.

REMARKS. Reported from nests of *Iridomyrmex* sp. (Oke, 1923). This species is known only from the type series.

Chlamydopsis compressipes Lea, 1919
(Figs 1C, 2C, 3)

Chlamydopsis compressipes Lea, 1919; Type ♀: *compressipes* [handwritten] Lea, Type, Mt Tambourine/ C/2086/ Type/ 10678, *Chlamydopsis compressipes* Lea, Queensland, QMB; examined, 2000.

RECORDS. QMB: SEQ: Mt Glorious, i-iii.1982 and ix-x.1990; CMN: Qld: Mt Glorious, 27°20'S,152°49'E, 3-9.x.1998, N. Power, MT.

DIAGNOSIS. This species is most easily recognised by its longitudinal laminae projecting up above the inner edges of the humeral trichomes. This is seen to a much lesser degree as well. However, in the latter species the laminae are oblique and do not project above the elevated humeri in *C. pallida*. The humeri are also much narrower, and the mediobasal elytral depression thus broader.

DESCRIPTION. L: 1.99; W: 0.75; E/Pn L: 1.67; E/Pn W: 1.29; Pn W/L: 1.42; E L/W: 0.91; Pr/Py: 1.13; Sterna: 0.50, 0.12, 0.62; Tibiae: 0.87, 0.93, 1.18. Body elongate, orange, mostly glabrous. Frons about 1.2× as long as wide, sides weakly arcuate, disk reticulopunctate, with a few short, inconspicuous setae; labrum broad, apical margin weakly bilobed, with a few short setae; antennal scape angulate near middle, rounded at apex; antennal club of female about two-thirds length of scape, that of male about 1.8× length of scape.

Pronotum about 1.5× as wide as long, sides margined, parallel in basal two-thirds, acutely widened and somewhat elevated anteriorly; lateral portions of anterior margin strongly elevated, arcuate, separated from lower central portion by stria which arcs behind base of lateral elevation, then curved posteriorly, meeting lateral pronotal margin at about the basal one-third; pronotal disk slightly depressed in anterior corners, with an acute, slightly transverse median tubercle, reticulopunctate throughout.

Prosternum with anterior margin sinuate, not grooved; prosternal keel transversely depressed at middle behind anterior margin, narrowed between procoxae, but widening slightly at apex, acutely emarginate, reticulopunctate throughout.

Elytra widest near humeri, humeri strongly though rather narrowly elevated, widened anteriorly, bluntly projecting forward at sides, the inner edges laminate, elevated above humeri from anterior edge to central trichome opening, lamina with a longitudinal setal fringe closely appressed to its outer surface, projecting very slightly above it, this fringe extending anteriorly to a short groove (probable homologue of 'superficial groove' of other species); central trichome opening mesal, small, circular, with a concealing fringe of downwardly directed setae; mediobasal elytral depression smooth, with low, blunt transverse carinae; elytral disks otherwise shallowly but uniformly reticulostrigose, with a few conspicuous setae near apex of humeri, otherwise glabrous; humeri of male, including inner lamina, generally less prominent.

Mesosternum about 4× as wide as long, projecting at middle, reticulopunctate; mesometasternal suture well impressed; median metasternal suture visible as a dark line, but not impressed, disk evenly, but very finely punctate; sternite 1 somewhat more coarsely punctate along basal margin and near metacoxae.

Legs more or less slender, slightly elongate; all tibiae of female with outer margins arcuate, their outer surfaces (and those of the femora less uniformly) densely but finely punctate, nearly alutaceous; protibia of male more nearly angulate near the base.

Propygidium weakly depressed along basal margin, otherwise evenly convex, shallowly reticulopunctate; pygidium convex, reticulopunctate in basal half, smooth apically.

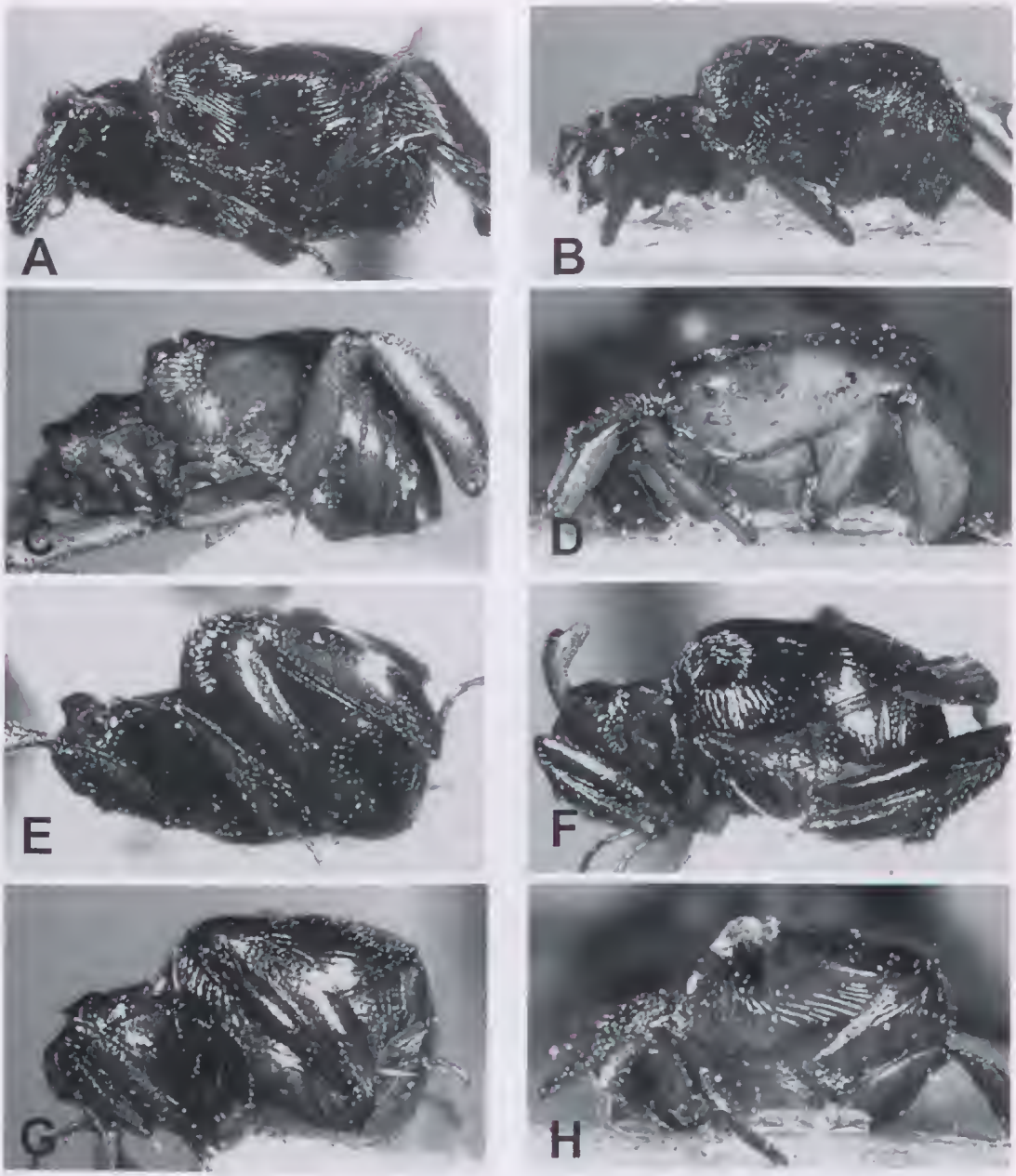

FIG. 2. Lateral views of *Chlamydopsis* spp. A, *C. striatipennis*. B, *C. leai*. C, *C. compressipes*. D, *C. pallida*. E, *C. rana*. F, *C. antennata*. G, *C. trichonota*. H, *C. reticulata* (♀).

REMARKS. The male and female specimens listed from Mt Glorious are slightly more elongate in body shape than the type of *C. compressipes*. However, with these three as all the known material of the species, they are considered to constitute a single variable species.

Chlamydopsis pallida Lea, 1918
(Figs 1D, 2D, 3)

Chlamydopsis pallida Lea, 1918: 86; Lectotype, hereby designated: New South Wales, Sydney, SAM; examined, 2000; 2 paralectotypes: same data as type, BMNH.

DIAGNOSIS. L: 2.31; W: 0.75; E/Pn L: 2.08; E/Pn W: 1.34; Pn W/L: 1.58; E L/W: 0.98; Pr/Py: 1.58; Sterna: 0.40, 0.16, 0.59; Tibiae: 0.87, 0.93, 1.15. *Chlamydopsis pallida* has very distinctive humeral trichomes. They are narrow and close to the anterolateral corners of the elytra, enclosing very little subhumeral space. This species also possesses a small oblique lamina (oriented posterolaterally) on the inner edge of the humeral trichome, around which the lateral portion appears to be curved. The pronotum is also distinctive, having the sides strongly elevated and the anterolateral groove deeply impressed.

REMARKS. Reported from the nest of a 'small reddish ant', identified, apparently tentatively, as *Meranoplus hirsutus*. An ant mounted with the paratypes is a *Meranoplus*, but I cannot confidently determine the species identity. Assuming the reported species is accurate, this would refer to what is now called *M. minor* Forel (based on its range), formerly *M. hirsutus minor*. This species is only known from the type series.

Chlamydopsis rana sp. nov.
(Figs 1E, 2E, 3, 30B)

MATERIAL. HOLOTYPE (QMT108574) ♂: Windsor Tableland via Mt Carbine, N Qld, 12.xi-26xii.1983. Storey & Walford-Huggins/ MDPI Intercept Trap, Site No. 14a, in QMB. PARATYPES (12): 4 ♀: same data as type; 3 ♀ ♀, 1 ♂: same locality as type but 26.xii.1983-24.i.1984; 1 ♀: Windsor Tableland, N Qld., 27.xii.88-9.i.1989, ES & ANZSES Site 5, FIT; 1 ♀: N Qld, Windsor Tableland, 38km from main road, 28.xi-20.xii.1985, RS&JB/ MDPI FIT site 14c; 1 ♂: NEQ: 15°48'S 145°17'E, Mt Finnigan, 1080m, 4.xii.1990-17.i.1991, QMB & ANZSES, FIT, Site 5; 1 ♀: NEQ. 15°52'S, 145°14'E, Mt Misery summit, 850m, 6.xii.1990-17.i.1991, QMB & ANZSES, FIT Site 3, in QMB, DPIM, MSCC.

DIAGNOSIS. This species is easily recognised by the combination of oblique, setose pronotal trichomes, and the broad, arcuate, elongate metatibiae. The only other *Chlamydopsis* which possess pronotal trichomes, *C. antennata* sp. nov. and *C. trichonota* sp. nov., have them restricted to the lateral margin, not forming an oblique setose depression. The metatibiae of these two species are also elongate, but not as broad as those of *C. rana*, at least in the known males.

DESCRIPTION. L: 2.06; W: 0.81; E/Pn L: 1.54; E/Pn W: 1.37; Pn W/L: 1.46; E L/W: 0.77; Pr/Py: 1.00; Sterna: 0.56, 0.12, 0.65; Tibiae: 0.87, 1.03, 1.34. Body dark, slightly rufescent brown, dorsally glabrous (except for trichomes), surfaces varied from smooth to coarsely strigose; frons with sides weakly rounded, about 1.2× as long as wide, reticulopunctate, with a pair of prominent apical marginal setae; labrum wide, faintly bilobed; antennal scape widest about one-third from base, rounded at apex; antennal club of male about 2× as long as scape, somewhat compressed; antennal club of female slightly shorter than scape.

Prothorax with lateral margins interrupted near front by notch-like trichome, the fringe of which extends more sparsely posteromesally along an oblique depression; anterior pronotal margin elevated, with central and lateral portions more or less continuous, though a fine stria extends from the anterior margin along the upper edge of lateral portions; pronotal disk smooth at middle, strigose at sides and along anterior margin.

Prosternum finely grooved along anterior margin, this groove diverging slightly from the margin at sides; anterior margin arcuate, more prominent at sides than at middle; disk of prosternal keel uniformly coarsely reticulopunctate, narrowed posteriorly, emarginate at apex.

Elytra 1.5× as wide as pronotal base, humeri strongly elevated, rounded at apices; setae of inner longitudinal fringe of trichome short, decumbent posteriorly, fringe arched above central opening of trichome, extending around front into horizontal anterior groove; central opening of trichome nearly obscured by downward pointing fringe of setae; dorsal aspect of trichome with elongate coarse setae, elytral disk otherwise glabrous, strongly reticulopunctate on upper and lateral surfaces of humeri, with a few transverse reticulae between trichomes, disk becoming smooth posteromedially; elytral marginal stria nearly complete, interrupted only slightly in mediobasal depression, not abruptly divergent from margin above metafemora.

Mesosternum about 5× as wide as long, projecting at middle, coarsely punctate; mesometasternal suture deeply impressed; metasternum with median longitudinal suture finely impressed, disk with only a few punctures in front of metacoxae; sternite 1 sparsely punctate at sides.

Femora slender, the metafemur about 1.3× length of pro- and mesofemur; protibia slender and angulate near basal one-third; mesotibia slightly broader, widest just beyond midpoint; metatibia elongate, broad, with outer margin more or less evenly rounded, dimorphic, with that of female about 1.3× as broad as that of male.

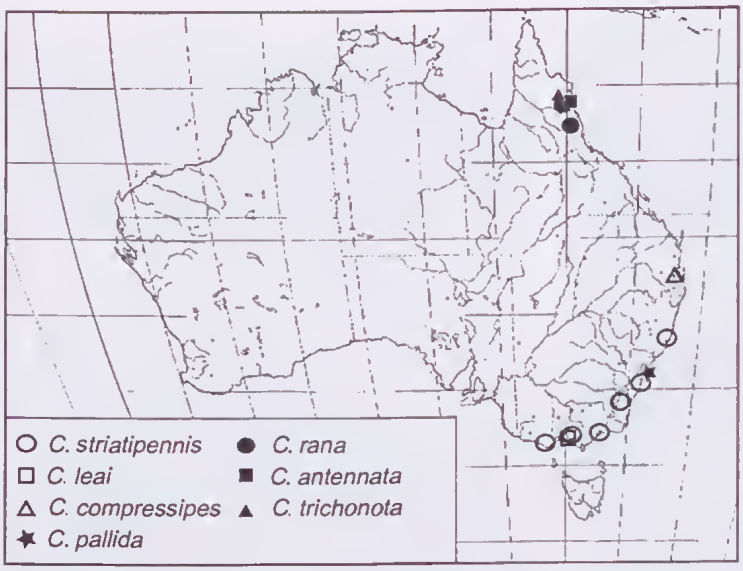

FIG. 3. Collecting records for species of *Chlamydopsis striatipennis* group.

Propygidium and pygidium faintly convex, both coarsely punctate, the pygidium becoming smooth and setose in apical one-third.

REMARKS: The name of this species refers the frog-like metathoracic legs, as well as its general appearance.

Chlamydopsis antennata sp. nov.
(Figs 1F, 2F, 3)

MATERIAL. HOLOTYPE (QMT108575) ♂: Windsor Tableland, N Qld., 27Dec 88-8 Jan 1989, E.Schmidt & ANZSES, Site 6, flt.intercept, in QMB. PARATYPES: 2 ♂♂: same data as holotype, in QMB.

DIAGNOSIS. As above, only this species, *C. rana*, and *C. trichonota* possess pronotal trichomes. In this species and the following, these are formed by short arcuate outgrowths of the lateral margins which meet externally to enclose a setose opening at the anterolateral pronotal corner, whereas in *C. rana* an oblique setose dorsal depression leads to a simple anterolateral notch. *Chlamydopsis antennata* and *C. trichonota* are very similar, and obviously closely related. *Chlamydopsis antennata* appears (from limited material) to be slightly smaller and, more significantly, the setose inner edge of the humeral trichome incises the elevated humerus more deeply, forming a distinct mesal emargination (Fig. 1F vs 1G).

DESCRIPTION. L: 2.12; W: 0.75; E/Pn L: 1.83; E/Pn W: 1.42; Pn W/L: 1.58; E L/W: 0.81; Pr/Py: 1.06; Sterna: 0.50, 0.12, 0.65; Tibiae: 0.93, 1.06, 1.43. Body dark, faintly rufescent, almost entirely glabrous. Frons 1.3× as long as wide, sides rounded, widest at middle, glabrous, entirely reticulopunctate; labrum broad, apical margin only slightly arcuate, with a few inconspicuous setae; antennal scapes with outer margins almost evenly arcuate, widest near middle, reticulopunctate; antennal club (of male) very large, about 3.5× as long as scape, apices projecting even when fully retracted, strongly compressed.

Prothorax about 1.5× as wide as median length; lateral margins with trichome, a small setose circular opening enclosed by anterior and posterior outgrowths of lateral margin, inflated base of posterior lobe with separate lateral setal fringe; anterior pronotal margin elevated, with central and lateral portions continuous, sinuate around large antennal cavities; pronotal disk glabrous, impunctate, shining.

Elytra with humeri strongly, rather narrowly, elevated in basal half, inner edge of each elevation emarginate, lined with continuous fringe of conspicuous setae concealing central opening of trichome, this fringe shorter anterior to emargination, extending anteriorly along inner edge around to anterolateral corner where it is longer, opposing posterolateral fringe of pronotum; mediobasal depression with strong transverse carinae; each elytron impunctate along suture, rather coarsely strigose at sides, the strigae converging (mesally and laterally) to apex of trichome; elytral marginal stria nearly complete, interrupted only slightly in mediobasal depression, not abruptly divergent from margin above metafemora.

Prosternum with anterior marginal stria deeply impressed, diverging from margin at sides, ending beneath anterior edge of pronotal trichome; prosternal disk shallowly reticulopunctate, narrowed posteriorly, keel depressed between procoxae, apex deeply and acutely emarginate.

Mesosternum short, about 6× as wide as long, projecting at middle, with a single row of

punctures; mesometasternal suture deeply impressed; metasternal disk impunctate; longitudinal metasternal suture faintly impressed; visible sternite 1 impunctate.

Legs all relatively slender, slightly elongate, the protibia and mesotibia about equal in length, outer margins angulate one-third from base, the metatibia 1.3 × as long, with outer margin evenly arcuate.

Propygidium arcuately depressed along basal margin, otherwise convex, shallowly but evenly reticulopunctate; pygidium evenly convex, reticulopunctate in basal half, smooth and with a few setae at apex.

REMARKS. Only males of this and the following species are known. Given the sexual dimorphism in metatibial shape, and possibly color, in the preceding species, the females of these species may differ slightly from the descriptions. The name of this species refers to the enormous antennal club of the males.

Chlamydopsis trichonota sp. nov.
(Figs 1G, 2G, 3)

MATERIAL. HOLOTYPE (QMT108576) ♂: Mt Lewis Rd, NEQld, 16km from Highway, 18 Dec 1989-13 Jan 1990, Monteith, Thompson, ANZSES, Site 2, 950m, Flt. Intercept. PARATYPE: 1 ♂: same data as type, in QMB.

DIAGNOSIS. L: 2.31; W: 0.81; E/Pn L: 1.85; E/Pn W: 1.45; Pn W/L: 1.54; E L/W: 0.83; Pr/Py: 1.13; Sterna: 0.62, 0.12, 0.72; Tibiae: 1.00, 1.06, 1.37. This species is very closely related to the preceding, and is therefore not fully described here. It differs most significantly in the form of the trichome. Its inner edge in this species is barely emarginate, the setal fringe arcuate posteriorly, but much closer to the typical straight line fringe of the *striatipennis* group. In addition, the elytra of this species are very sparsely, but evenly clothed with fine setae. *Chlamydopsis antennata* has at most a few decumbent hairs on the anterior surface of the trichome, but none elsewhere. Otherwise the two species appear virtually identical.

REMARKS: The name of this species refers to its pronotal trichomes.

STRIGICOLLIS GROUP

The *strigicollis* group contains seven apparently relatively generalised species. They are characterised by an anterior superficial humeral groove that extends more or less obliquely and horizontally from the humeral elytral corner inward to the mesal base of the trichome. They are further restricted to those species in which anterior prosternal marginal stria does not depart from the margin to meet the circumcoxal stria. This marginal stria does not form a conspicuous groove in the first four species included here. But it does in the last three, which for that reason are included somewhat tentatively. The form of the trichome suggests relationships with the *pygidialis* group. However, the latter is so readily characterised that both are maintained as separate groups until a clearer phylogenetic picture emerges. The first three species of this group exhibit an oblique groove running behind the lateral portion of the anterior pronotal margin. This is identical in form to that of most of the *striatipennis* group, although this seems likely to be a symplesiomorphy.

Chlamydopsis reticulata Lea, 1910
(Figs 1H-I, 2H-1, 6, 29D)

Chlamydopsis reticulata Lea, 1910: 199; Material. Holotype (unique): *reticulata* Lea, Type, N.S.W./, on the underside of mounting card: *reticulata* Lea TYPE, from King's coll./ *Chlamydopsis reticulata* Lea, Type, Australia; SAM, examined, 2000; these specimen data conflict with Lea's original citation of the type specimen: 'Australia (a single specimen, without locality label, from the late Rev. R. L. King's collection)'; it is thus unclear why 'N.S.W.' appears on the type label.

Chlamydopsis excavata Lea, 1910: 200; Type: Tasmania, near Hobart; SAM, not examined; New Synonymy.

Chlomydopsis puncticollis Oke, 1923: 156; Lectotype ♂, hereby designated: Ferntree Gully, 26.5.1920, C. Oke, Vic./ *Chlamydopsis puncticollis* Oke Type/ Presented by C.G. Oke/ 897 Type; Paralectotype ♂: same locality, 20.6.20, 898 Paratype; MVM, examined, 2000; New Synonymy.

RECORDS. ANIC: ACT: 35.16S, 149.06E, Black Mt, 600m, x.1987. NHM: NSW: Sydney [as *C. excavata*, det. by A. Lea]. Lea (1919): NSW: Hunters Hill (nr Sydney), Oct., nest of *Ectatomma* [as *C. excavata*]; Vic: Fern Tree Gully, Dec. [as *C. excavata*]. Lea (1925): NSW: Como, *Ectatomma metallicum*. Oke (1923): NSW: National Park; Vic: Beaconsfield; Vic: Belgrave; Vic: Ferntree Gully [as *C. puncticollis*]. MCZ: Vic: Beaconsfield.

DIAGNOSIS. L: 2.15; W: 0.72; E/Pn L: 2.00; E/Pn W:1.39; Pn W/L: 1.57; E L/W: 0.92; Pr/Py: 1.00; Sterna: 0.62, 0.12, 0.69; Tibiae: 0.81, 0.87, 1.00. This and the following species are very similar. Both exhibit sexual dimorphism in the sculpturing of the elytra, with the males being reticulostrigose everywhere outside the mediobasal depression, and the females appearing almost entirely impunctate. In both sexes the pronotal texture differs slightly between the two species, with the strigae of *C. reticulata* more consistently impressed from edge to middle. In

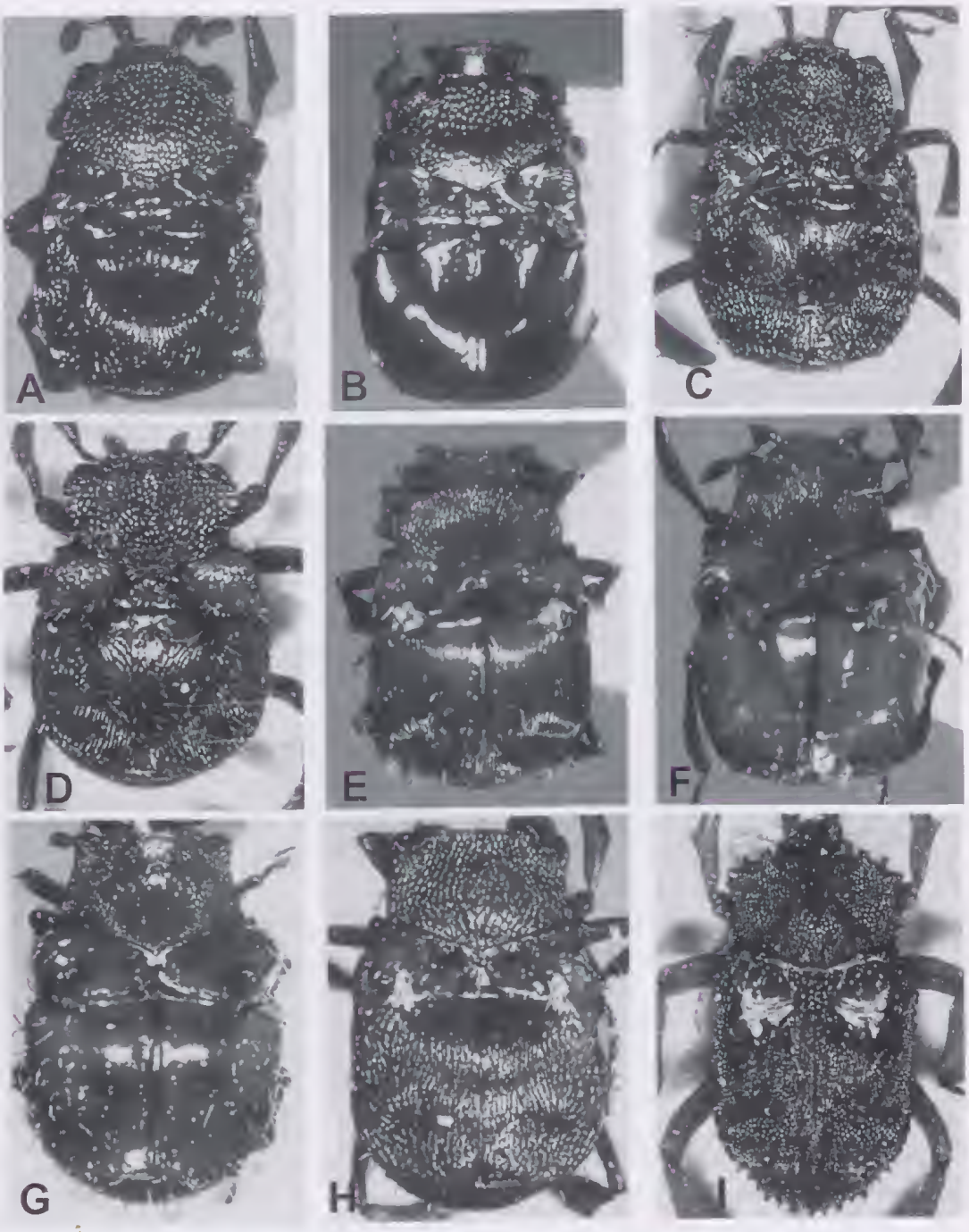

FIG. 4. Dorsal views of *Chlamydopsis* spp. A, *C. dimorpha* (♂). B, *C. dimorpha* (♀). C, *C. strigicollis*. D, *C. mormolyce*. E, *C. monteithi* (♂). F, *C. monteithi* (♀). G, *C. setifera* (♀). H, *C. lawrencei* (♂). I, *C. pygidialis*.

most specimens of *C. dimorpha* the strigae/punctures of the median portion of the pronotal disk are less deeply impressed, and it is often impunctate at the centre. While *C. reticulata* is consistently slightly larger than *C. dimorpha*, this is especially evident in the elytra

of the females, with those of *C. reticulata* much broader relative to the pronotum. Possibly the most consistent, though least substantial, difference is that the mediobasal depression of *C. dimorpha* always possesses a minute setigerous pustule at the sides near the trichome (occasionally more than one), whereas in all *C. reticulata* examined so far, the mediobasal depression is bare (except along the fine transverse carina).

REMARKS. The new synonymies proposed here are based partly on the sexual dimorphism discovered in this species. In fact Lea (1910) recognised the strong structural similarity between his *reticulata* and *excavata*, but had no reason to expect such a striking difference to be sexual. Oke (1923), however, seems to have been simply unfamiliar with *C. reticulata*, as it is not mentioned in his description of *C. puncticollis*.

Chlamydopsis dimorpha sp. nov.
(Figs 4A-B, 5A, 6)

MATERIAL. HOLOTYPE (QMT108577) ♂ (dissected by the author): NEQ: 17°26'S, 145°42'E, Hughes Road, Topaz, 6 Dec1993-25 Feb 1994, Monteith, Cook, Janetzki, RF Intercept, 650m. PARATYPES (20): 11 ♂, 1 ♀: same data as holotype; 1 ♀: SEQ: 27°20'S, 152°48'E, Stony Ck., via Samford, 22.x.94-2.ii.1995, HJ&GM, RF FIT; 1 ♀: same as preceding but 2.ii-8.iv.1995, open forest FIT; 1 ♂: NEQ: 17°24'S, 145°41'E, Westcott Rd, Topaz, 6.xii.93-25.ii.1994, GM,DC,HJ, RF FIT, 680m; 1 ♀: NEQ: 17°24'S, 145°41'E, PEI Rd, Topaz, 6.xii.93-25.ii.1994, GM,DC,HJ, RF FIT, 580m; 1 ♂: NEQ: Danbulla SF, 13km NE of Yungaburra, 20.xii.86-13.i.1987, RS&SD, MDPI FIT site 27; 1 ♂: Qld: 17.28S 145.29E, Longlands Gap BS1, 1150m 3.i-5.ii.1995, PZ, FIT; 1 ♀: SEQ: 25°40'S 151°25'E, Nipping Gully, Site 2, 9.x-18.xii.1998, GM&Gough, RF FIT, 200m, 7399; 1 ♂: Qld: 28°08'S 152°40'E, Black Rock Scrub, 350m, 2.xii.2000-13.v.2001, GM, RF FIT, 10162, in QMB, DPIM, ANIC, MSCC.

DIAGNOSIS. See diagnosis under *C. reticulata*, above.

DESCRIPTION. L: 1.99; W: 0.69; E/Pn L: 1.91; E/Pn W: 1.29; Pn W/L: 1.55; E L/W: 0.95; Pr/Py: 0.93; Sterna: 0.56, 0.12, 0.59; Tibiae: 0.75, 0.87, 0.87. Body dark reddish brown, subquadrate. Frons slightly wider than long, sides approximately parallel in apical 2/3, narrowed at antennal bases and at apex; with strongly developed reticulate sculpturing, the individual cells varied but most elongate oval or elongate polygonal; labrum semicircular, faintly rugose, with a few elongate setae. Antennal scapes with outer edges bluntly angulate, widest just apicad of midpoint, reticulately sculptured as frons; antennal club of female oval, approximately equal in length to funicle; antennal club of male more elongate, about 1.5× as long as funicle.

Pronotum almost 2× as wide as long, margined laterally, sides very slightly arcuate, but more or less parallel, anterior margin tripartite, in lateral thirds (above antennal cavities) raised nearly perpendicular to disk, oblique and slightly inwardly arcuate to side, in middle third less strongly raised, the middle section separated from lateral oblique sections by a groove which continues posterolaterally along base of raised lateral margin, curving posteriorly near side where it merges with lateral pronotal margin; pronotal disk reticulately sculptured, the reticulae elongated and oblique anterolaterally, less strongly sculptured posteromedially, especially in female.

Prosternum with reticulately sculptured lobe and keel separated from smooth depressions for reception of legs by a strong carina extending from lateral sternal margin to base of keel; keel strongly narrowed posteriorly, acutely emarginate at base; keel set off from lobe by a weak transverse furrow at middle, reminiscent of (though probably not homologous with) the presternal suture of many histerids; anterior margin of prosternum simple (with weak marginal stria but not grooved) weakly arcuate at sides, transverse and faintly undulating at middle.

Each elytron about 2× as long as wide, widest just behind middle; transversely depressed across middle at base, trichome with anterior and posterior portions strongly elevated; anterior elevation with anterior superficial groove strongly oblique from anterior elytral corner to near base of inner edge of trichome, bearing a dense continuous fringe of golden setae from this groove up inner edge of trichome to its apex, the setae apparently increasing in length towards apex, the apical-most setae extending over the gap between anterior and posterior elevations of trichome; gap between elevations incised nearly to their bases internally and externally, the external incision a narrow, inverted 'Y' shape, lacking setae, the inner incision broadly open, with anteriorly directed setae on posterior edge from near base to apex; sculpturing of elytral disk strongly sexually dimorphic: that of male with elongated reticulae everywhere except in depression between trichomes, that of female absolutely smooth except on epipleuron and anterior slope of trichome which are reticulate as in male; elytral disk of both sexes with few

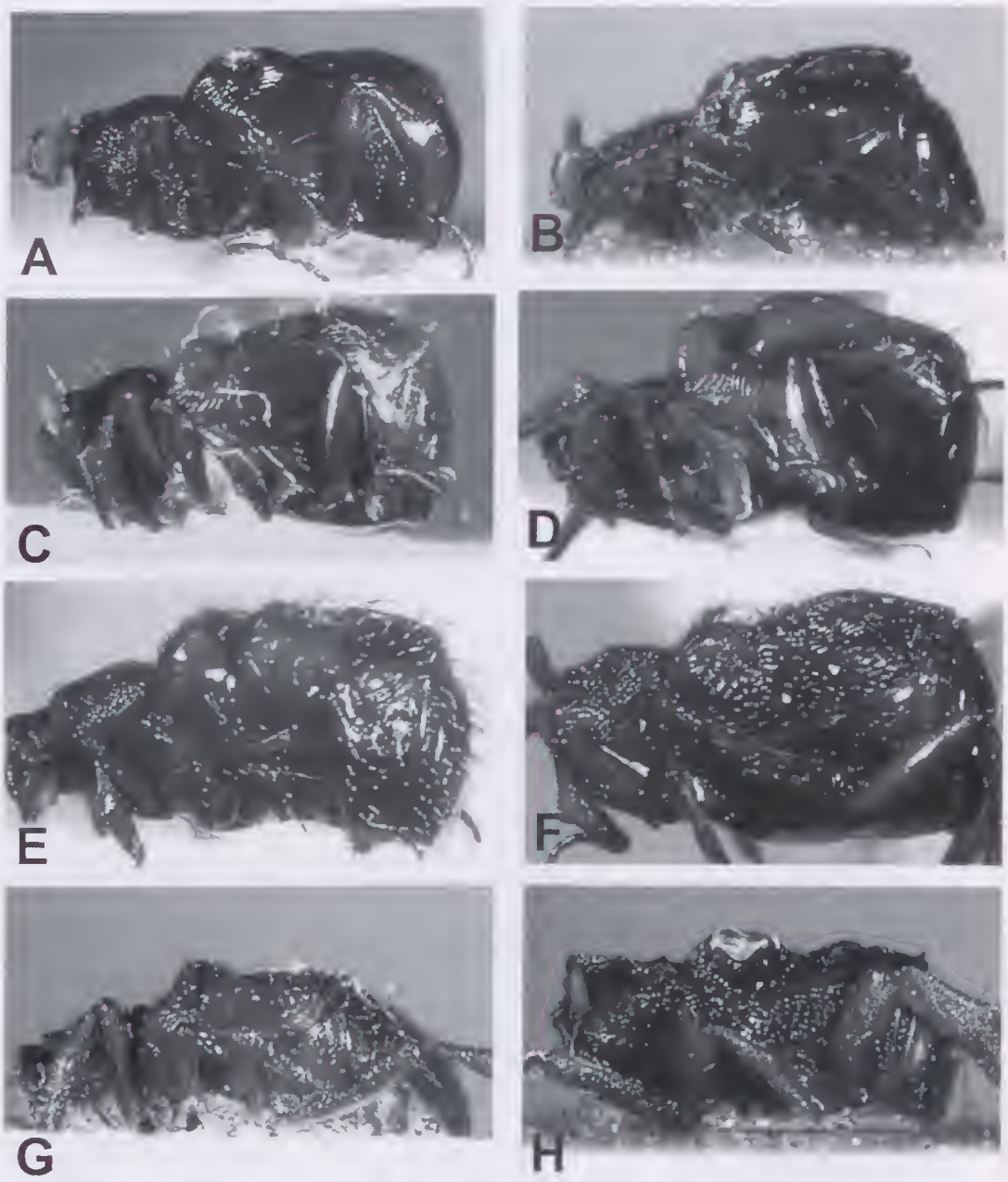

FIG. 5. Lateral views of *Chlamydopsis* spp. A, *C. dimorpha* (♂). B, *C. strigicollis*. C, *C. mormolyce*. D, *C. monteithi* (♂). E, *C. monteithi* (♀). F, *C. setifera* (♀). G, *C. lawrencei* (♂). H, *C. pygidialis*.

conspicuous setae along basal half of elytral suture, and a few at sides within the medial depression; marginal stria of elytron continuous along all edges except along base and medial suture near scutellum.

Mesosternum about 3× as wide as long, acutely projecting at middle, with complete anterior marginal stria, posterior margin sinuate, raised relative to anterior portion of metasternum, disk with scattered punctures and dense

intervening microsculpture. Metasternum smooth, without hint of microsculpture, with only a few weak punctures along anterior edge and scattered inconspicuous setae. First visible abdominal sternite similarly smooth and with faint anterior marginal punctures.

Prothoracic legs densely reticulate on exposed surfaces, tibia slender, with outer edge angulate one-third from base; meso- and metathoracic legs smoother, with only faint microsculpture along outer tibial margins; posterior tibiae slightly broader and more rounded than protibia, tibiae of female markedly broader and rounder, and with microsculpture confined to a discrete marginal band.

Propygidium shallowly depressed at middle of anterior margin, otherwise uniformly convex, densely reticulate throughout; pygidium weakly convex, with weakly developed reticulae in basal one-third, otherwise smooth.

REMARKS. The name of this species refers to the marked difference between the sexes.

Chlamydopsis strigicollis Oke, 1923
(Figs 4C, 5B, 6)

Chlamydopsis strigicollis Oke, 1923: 157; Lectotype, hereby designated: Belgrave, V., 17.10.21, C.Oke/ *Chlamydopsis strigicollis* Oke, Type/ Presented by C.G. Oke/ 899.

MATERIAL. HOLOTYPE ♂; MVM, examined, 2000. Paralectotype: same data as lectotype; in MVM.

RECORDS. Oke (1923): Vic: Hurst's Bridge; Vic: Ferntree Gully; Vic: Beaconsfield; Vic: Mooroolbark. WAM: Vic: Ferntree Gully. ANIC: ACT: 35.19S, 148.51E, Wombat Ck, 6km NE Picadilly Circus, i.1984, 750m; Vic: Withers, 2-42; NSW: 32.08S, 151.27E, Allyn River, Chichester SF, 10-11.xi.1981. MCZ: Vic: Arthur's Seat, 900ft., 29.iv.1951, 'w/*Chalcoponera victoriae*'.

DIAGNOSIS. L: 1.93; W: 0.75; E/Pn L: 1.58; E/Pn W: 1.35; Pn W/L: 1.42; E L/W: 0.83; Pr/Py: 1.21; Sterna: 0.56, 0.12, 0.44; Tibiae: 0.69, 0.69, 0.69. Among members of this group, *C. strigicollis* is unique in having the anterior pronotal margin barely upturned relative to dorsum. It also lacks the oblique lateral groove behind the antennal cavities, present in *C. reticulata* and in *C. dimorpha*. The pronotal texture and setation are also unique; the disk is reticulostrigose, with the strigae and the long, decumbent setae convergent anteromedially. Interestingly, *C. strigicollis* does not exhibit the elytral dimorphism shown by *C. reticulata* and in *C. dimorpha*; both sexes are uniformly reticulostrigose.

REMARKS. Reported from nests of *Chalcoponera* sp. (Oke, 1923).

Chlamydopsis mormolyce Lea, 1925
(Figs 4D, 5C, 6)

Chlamydopsis mormolyce Lea, 1925: 255; Lectotype, hereby designated: *Mormolyce*, Mundaring, Lea, Type/ *Chlamydopsis mormolyce* Lea Type, W. Australia, mounted with host ant; SAM; examined, 2000.

RECORDS. WAM: WA: Culham, xi.1960, nest of *Chalcoponera inornata*.

DIAGNOSIS. L: 2.18; W: 0.84; E/Pn L: 1.59; E/Pn W: 1.51; Pn W/L: 1.30; E L/W: 0.81; Pr/Py: 1.11; Sterna: 0.65, 0.16, 0.59; Tibiae: 1.00, 1.12, 1.21. While *C. mormolyce* shares the orientation of the anterior superficial humeral groove with the other members of this group, the actual form of the trichome differs somewhat from the others. Firstly its upper mesal edge, densely fringed with setae in the other species, is bare; the only trichome setae are within its opening, barely visible from above. The anterior surface of trichome is broad, slightly concave. There is also no lateral gap between the anterior and posterior humeral elevations. Although a conspicuous shallow groove marks the junction, they are solidly joined to their dorsal apices. A few additional distinguishing characters include: pronotal reticulae all more or less polygonal, none elongate; prosternum bearing setae; metasternum and sternite 1 faintly reticulate throughout, more conspicuously towards the anterior margin of each; elytral disks with elongate reticulation, and long, though sparse, setae; legs of female all elongate, slender and reticulate (posterior ones not smooth); inner apex of meso- and metatibiae with an acute, fixed denticle.

REMARKS. The numerous differences between this and the other species of the *strigicollis* group leave some doubt that it belongs here phylogenetically. Its relationships will require reassessment with more extensive samples.

Chlamydopsis monteithi sp. nov.
(Figs 4E-F, 5D-E, 6, 28B)

MATERIAL. HOLOTYPE (QMT108578) ♂: C.Qld 26°57'S 148°02'E, Mt Moffatt NP, 1000m, Mahogany Forest, 26 Sept-26 Nov 1995, G. Monteith. Intercept. PARATYPES: 7 ♀♀, same data as type, in QMB, DPIM, MSCC.

DIAGNOSIS. This and the following two species exhibit unusual anterior prosternal margins. Its marginal stria does not diverge from the margin at

the sides to meet the circumcoxal stria (as it does in the preeeding speeies), but it is eonspicuously grooved, as in many *Chlamydopsis* outside of this group. While the prosternal strial eonfiguration is likely a symplesiomorphy, the form of the superficial humeral groove of the trichome (strongly oblique, entering the trichome near its mesal base) is a more unusual character supporting their placement in the *strigicollis* group. The females of this species and *C. setifera* are particularly similar (though only the female of the latter is known), sharing smooth elytra bearing elongate sparse setae, and essentially identical trichome shape. The prineipal differenee between them is that *C. setifera* bears elongate isolated setae on the propygidia and all ventrites as well as dorsally. The pygidia and venter of *C. monteithi* are glabrous. The males of *C. monteithi* and *C. lawrencei* are generally similar, but the latter is smaller (2.37mm vs 2.31mm), less densely strigose, and has the humeral triehomes smaller and slightly more distant from the sides.

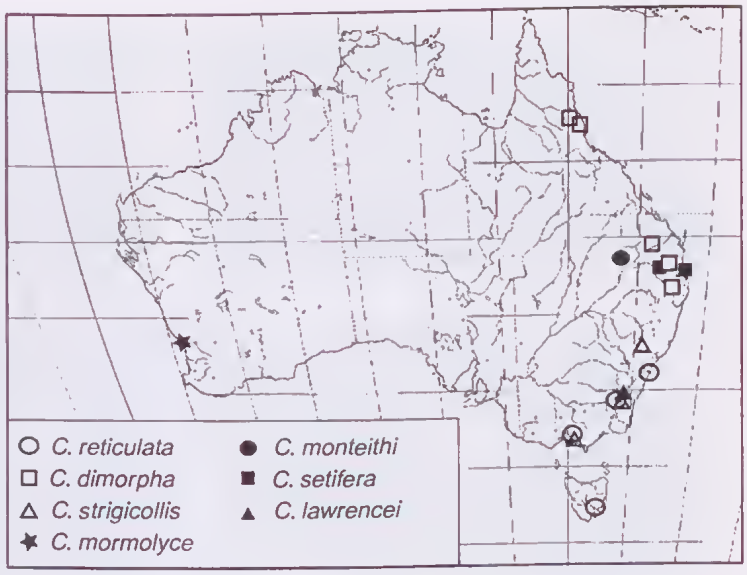

FIG. 6. Collecting records for species of *Chlamydopsis strigicollis* group.

DESCRIPTION. L: 2.37; W: 0.84; E/Pn L: 1.81; E/Pn W: 1.31; Pn W/L: 1.56; E L/W: 0.89; Pr/Py: 0.95; Sterna: 0.75, 0.16, 0.72; Tibiae: 0.87, 0.87, 0.97. Body rufeseent, bearing numerous elongate, single setae; frons slightly wider than long, sides strongly rounded, apical margin weakly rounded; frontal disk flat, densely retieulopunetate, bearing 1-2 elongate setae; labrum subaeute at apex, faintly punetate, with short sparse setae at apex; antennal seapes bluntly angulate near middle, narrowed to base and more gradually to apex, densely retieulostrigose.

Pronotum about 1.4× as wide as long, sides unmargined (though appearing submargined in posterior half where earina delimiting proleg depression intrudes), widest near base, slightly sinuately narrowed to apex; anterior margin weakly elevated above antennal cavities (more distinetly so in male), medial portion shallowly inwardly arcuate; pronotal disk slightly depressed in anterior corners, eonvex posteriorly, densely reticulostrigose, strigae eonverging to scutellum, bearing a few (exaetly 4 in most of type series) elongate setae, some of them 'bundles' from conspicuous punctures.

Prosternum with anterior margin finely but distinetly grooved, the groove only slightly diverging from margin at sides, not joining cireumeoxal stria, but meeting the pronotal/prosternal marginal groove near the anterolateral pronotal eorner; anterior prosternal margin slightly deflexed, sinuate, rounded at middle, without lateral projeetions; prosternal keel narrowed posteriorly, very shallowly emarginate at apex, with fine marginal stria along inner edge of leg depression, but not along apical margin of keel; prosternal disk fairly evenly punctate, more shallowly so along medial portion of anterior margin, glabrous.

Elytra about 1.3× as wide as base of pronotum; widest elose to base, sides parallel in basal two-thirds, rounded to apiees; humeri strongly elevated (more so in females), anterior and posterior elevations divided by transverse furrow, this furrow deeper and broader mesally than laterally, densely setose on posterior and espeeially anterior mesal edges; anterior superficial humeral groove fine, oblique, nearly horizontal, entering mesal base of trichome opening; mediobasal depression oecupying less than basal half of elytra, with fine transverse earinae from just behind seutellum eurving posterolaterally to middle of trichome opening; dorsum of elytral disk of female smooth,

impunetate except for widely scattered setigerous punctures, each with elongate seta (few with multiple setae), these subserially arranged behind trichome and along posterior half of elytral suture; elytral disk of male finely, longitudinally reticulostrigose in apical two-thirds, with similarly sparse setigerous punctures; epipleuron strigose in both sexes, strigae converging to trichome; posterior elytral margin not carinate; elytral marginal stria continuous around lateral and posterior margins, but entirely absent along suture.

Mesosternum about 3× as wide as median length, weakly projecting at middle, disk densely punctate; mesometasternal suture finely but crenulately impressed, continuous at sides with postmesocoxal stria; median longitudinal metasternal suture not impressed, but visible; metasternal disk and 1st abdominal sternite impunetate, glabrous; legs short, slender, with short fine setae; profemur and tibia faintly punctate, meso- and metatibiae and femora impunetate; outer margin of protibia acutely angulate at basal one-third, meso- and metatibiae more bluntly angulate nearer their midpoints.

Propygidium convex, densely but very shallowly reticulopunctate in male, reticulae only barely visible in female; pygidium of male faintly reticulopunctate in basal half, impunetate apically, that of female impunetate; pygidia in both sexes glabrous.

REMARKS. This species is named in honor of Geoff Monteith, collector of this species' entire type series, whose field efforts have contributed enormously to chlamydopsine studies.

Chlamydopsis setifera sp. nov.
(Figs 4G, 5F, 6)

MATERIAL. HOLOTYPE (QMT108579) ♀: SEQ: 26°53'S 152°09'E, Benarkin School, 14 Nov1994-26 Jan 1995, G.B.Monteith, Intercept trap, open forest. PARATYPE ♀: Qld: 27°33'S 153°28'E, N.Stradbroke I.,Enterprise Blackbutt #1, 90m, 8-22 Jan 2002,QM party pitfall trap 10343.

DESCRIPTION. L: 2.31; W: 0.81; E/Pn L: 1.85; E/Pn W: 1.53; Pn W/L: 1.46; E L/W: 0.83; Pr/Py: 0.95; Sterna: 0.69, 0.12, 0.72; Tibiae: 0.87, 0.81, 0.90. This species exhibits only a few differences from the females of the *C. monteithi*, described fully above. They differ primarily in distribution of setae. The elongate setae of this species are more evenly distributed on the body. The pronotum bears setae along the anterior and lateral margins, rather than just at middle; setae of the elytra extend up the entire length of the suture (rather than being confined to its apical half); the pygidia, legs and ventrites all bear elongate setae completely lacking in the preceding species; pronotal reticulae faint at middle, obsolete in apical half. There is an additional possible difference in the form of the trichome. On the left side of the type (but not the right) the furrow between anterior and posterior elevations is more deeply and finely incised than in the preceding species. However, this may result from ant damage, as this is where ants are known to grasp the beetles in their mandibles.

REMARKS. Although males of this species are not yet known, it is likely that the species is dimorphic, and that the males will have the elytra densely reticulostrigose, as in the preceding species.

Chlamydopsis lawrencei sp. nov.
(Figs 4H, 5G, 6)

MATERIAL. HOLOTYPE ♂: 35.16S 149.06S [sic] ACT, Black Mtn. Canberra, 25 Oct.1990, J.F.Lawrence, sweeping; in ANIC. PARATYPE: 1 ♂: ACT: 36.16S 149.05 ACT Black Mtn.W. slope,5.xii.1989, T. Weir, Berlesate ANIC 1125, open forest litter; in ANIC.

DIAGNOSIS. As above, this species is unusual in having the anterior prosternal margin grooved but with the groove not diverging at the sides to meet the circumcoxal stria. This species, known only from the two males, is likely sexually dimorphic like the preceding two. This male differs from the male of *C. monteithi* in its smaller body size, shorter, more convex pronotum, and smaller, more narrowly separated humeral trichomes.

DESCRIPTION. L: 2.31; W: 0.81; E/Pn L: 1.85; E/Pn W: 1.43; Pn W/L: 1.42; E L/W: 0.91; Pr/Py: 0.80; Sterna: 0.69, 0.12, 0.72; Tibiae: 0.84, 0.87, 1.00. Body dark rufescent; frons about 1.2× as wide as long, sides strongly rounded, margins elevated, mostly flat, faintly depressed between antennal bases; frontal disk reticulopunctate, with a few fine setae; labrum rounded, shallowly punctate; outer margin of antennal scapes bluntly angulate near midpoint, baso- and apicolateral margins straight, apex rounded; antennal club about 1.4× as long as antennal scape.

Prothorax about 1.3× as wide as median length, approximately equal in width basally and apically, slightly narrowed at middle, unmargined in anterior half, outer edge of prosternal leg depression projecting beyond

margin in posterior half (such that it appears margined from above); lateral thirds of anterior margin strongly arcuate, elevated; median portion only very weakly elevated; pronotal disk shallowly depressed in anterior corners, otherwise convex, with subacute median tubercle.

Prosternum with anterior margin finely grooved, the groove only slightly diverging from margin at sides, not joining circumcoxal stria, but meeting the pronotal/prosternal marginal grove near the anterolateral pronotal corner; anterior margin slightly deflexed, uneven, not projecting at sides; prosternal keel narrowed posteriorly, shallowly emarginate at apex; prosternal disk reticulopunctate, glabrous.

Elytra about 1.3× as wide as base of pronotum, sides nearly straight, slightly convergent to front; humeri moderately elevated, not incised laterally, trichome a mesally open semicircle, with an uneven inner setal fringe, the posteriorly directed setae of the anterior edge overlaying those of the posterior edge; anterior superficial humeral groove fine, oblique, extending from the humeral corner medially along the anterior elytral margin for a short distance before curving back to enter the anteromesal base of the trichome opening; mediobasal depression short, confined to basal one-third, with low, obliquely transverse basal carinae; apical elytral margin weakly carinate; elytral disk reticulostrigose; with scattered elongate setae throughout.

Mesosternum about 4× as wide as median length, weakly projecting anteriorly, disk densely punctate; mesometasternal suture finely impressed, continuous at sides with postmesocoxal stria; median longitudinal metasternal suture faintly impressed; metasternal disk with few fine punctures, glabrous, with faint alutaceous microsculpture; 1st abdominal sternite with row of fine punctures along anterior margin, with a few scattered punctures behind; legs short, slender, minutely setose; outer surfaces of profemur and tibia faintly punctate, meso- and metatibiae and femora impunctate; outer margin of protibia acutely angulate at basal one-third, meso- and metatibiae more bluntly angulate.

Propygidium shallowly reticulopunctate, with sparse elongate setae; pygidium very shallowly reticulopunctate in basal one-third, nearly smooth apically.

REMARKS. The female of this species is not known. Discovering that it shared the dimorphism in elytral texture with *C. monteithi*, above, would support its position in this group. The species is named in honor its type's collector, coleopterist par excellence John Lawrence.

PYGIDIALIS GROUP

While a few of the species in this group are extremely distinctive and closely related, it is in fact a rather varied group, with only a few species showing the radical serrate and tuberculate surfaces seen in the nominate species. All of the species possess some form of frontal tubercles, usually in two longitudinal rows of three each, although 2 and 4 tubercles/row have also been seen. The humeral trichome is very consistent in shape (with the exception of *C. setipennis*; see below), forming a horizontal C-shaped arc originating nearly at the humeral corner. Its setal fringe (again with the exception of *C. setipennis*) extends along this arc, and is either continuous through the lateral notch (the posteriormost point of this arc) and along the anterior edge of the posterior trichome elevation, or is interrupted at the lateral notch. The anterior superficial humeral groove in these species is also continuous with this arc, extending from anteromesal base of the trichome to the humeral corner. Most species also exhibit the following characters: transverse propygidial carina, median pronotal tubercle present, often forming short transverse ridge (often also with longitudinal carina leading to anterior pronotal margin), lateral pronotal margins elevated, metatibiae often expanded. There is little question that the species included here are closely related. However, some characters suggest derivation of the *longipes* group from among them.

Chlamydopsis pygidialis Blackburn, 1900
(Figs 4I, 5H, 9)

Chlamydopsis pygidialis Blackburn, 1900: 206; Type: Australia; NHM, examined, 2000.

Chlamydopsis pygidialis var. *minor* Oke, 1923: 153; Mazur, 1984; Lectotype, hereby designated: Ferntree Gully, 16.5.1920, C.Oke, Vic./ *Chlamydopsis pygidialis* var. *minor* Type/ Presented by C. Oke/ 891 Type; MVM, examined, 2000.

RECORDS. NHM: Vic: nr. Melbourne, vi.1920; ACT: Canberra, Black Mt, vii.1974, under stones. WAM: Vic: Ferntree Gully. AMS: Vic: Millgrave. Lea (1925): Vic: nr Melbourne, May, with Iridomyrmex. Oke (1923): Beaconsfield; Belgrave; Healesville; Warburton; Yarra Junction; Emerald; Pakenham [all Vic].

DIAGNOSIS. *Chlamydopsis pygidialis* shares many characteristics with the following 3 species. All have the lateral and anterior pronotal margins strongly elevated, and the posterior margin of each elytron strongly carinate, with the

carina extending forward along the lateral margins (extending nearly to the elytral base in *C. pygidialis*, *C. serricollis*, and *C. carinicollis*). These last three also have a strong median longitudinal carina from the median pronotal tubercle extending forward to the margin. Of the four species, all but *C. carinicollis* have this carina at least slightly to strongly serrate. *Chlamydopsis setipennis* is easily separated from the remaining three by the humeral trichomes in which the anterior elevation is nearly or fully vertical, and separated from the posterior elevation by a broad notch lined by a long, unkempt setal fringe. *Chlamydopsis pygidialis* and *C. serricollis* are the most similar of the group, having pronotum, elytra and propygidium strongly serrately margined. The most distinctive character separating the two is the oblique apical margin of the metatibia, which in *pygidialis* departs about 75° from the long axis of the tibia. This angle is closer to 45-50° in *C. serricollis*. The metatibia is less strongly narrowed towards the base in *C. pygidialis*. Lea (1914b) cited the medial longitudinal carina of the pronotum as being more conspicuously serrate in *C. serricollis* than in *C. pygidialis*.

REMARKS. Blackburn (1891) reported that the type was 'obtained by beating dead branches and probably connected with some species of Hymenoptera inhabiting the dead wood'.

Chlamydopsis carinicollis Lea, 1919
(Figs 7A, 8A, 9)

Chlamydopsis carinicollis Lea, 1919: 178; Type locality: Vic: Beaconsfield; SAM, not examined.

RECORDS. NHM: Vic, (Det. A. Lea); Oke (1923): Vic: Ferntree Gully; Vic: Upwey, *Chalcoponera* sp.

DIAGNOSIS. As above, this species shares the carinate apical elytral margin and the median longitudinal pronotal carina with *C. pygidialis* and *C. serricollis*. However, in *C. carinicollis* these carinae are not serrate as they are in the other two. The humeral trichome of this species is also relatively small, and does not incise the lateral aspect of the humeri.

REMARKS. The type was reported from a nest of the ant *Aphaenogaster longiceps* in July (Lea, 1919). Of currently recognised subspecies, only *A. l. longiceps* (Smith) occurs near the type locality of *C. carinicollis*.

Chlamydopsis serricollis Lea, 1914
(Figs 7B, 8B, 9)

Chlamydopsis serricollis Lea, 1914b: 217; Type: *serricollis* Type Lea, Pt. Hacking/ *Chlamydopsis serricollis* Lea type, N. S. Wales; mounted with 1 ant, reportedly *Ectatomma metallicum* (Lea, 1914b); in SAM; examined.
Chlamydopsis serricornis; Mazur, 1997: 4; misspelling.

RECORDS. NHM: NSW: Sydney. Lea (1925): NSW: nr Sydney, *Ectatomma metallicum*.

DIAGNOSIS. See the diagnosis under *C. pygidialis* above.

Chlamydopsis setipennis Oke, 1923
(Figs 7C, 8C, 9)

Chlamydopsis setipennis Oke, 1923: 154; Lectotype, hereby designated: Evelyn.V., 5.6.22, C.Oke/ *Chlamydopsis setipennis* Oke Type/ Presented by C.Oke/ 893 Type, MVM, seen, 2000; Paralectotypes: Belgrave, Vic., 16.10.21, C.Oke/ *Chlamydopsis setipennis* Oke Co-Type/ 2149 Paratype/ F.E. Wilson Collection, MV; Belgrave, Vic., 3.7.21, C. Oke/ *Chlamydopsis setipennis* Oke Co-Type/ Presented by C. Oke/ 894 Paratype, MVM; Belgrave, Vic., C. Oke, AMS; Ferntree Gully, Vic., C. Oke, NHM; Victoria: Emerald, Sep 26, 1920, Oke, NHM.

DIAGNOSIS. *Chlamydopsis setipennis* is quite distinctive within the *pygidialis* group. The form of its humeral trichome is unique, having the anterior and posterior elevations quite broadly separated, with a large lateral notch between them. The setal fringe of each is also unique, with the setae of the anterior elevation being elongate, rather sparse, and nearly erect, while those of the posterior elevation, also unusually elongate, are clustered into two distinct, adjacent 'clumps'.

REMARKS. Described as inhabiting the nests of *Notoncus foreli* Andre var. *dentatus* Forel (Oke, 1923). This species is known only from the type series.

Chlamydopsis convergens sp. nov.
(Figs 7D, 8D, 9)

MATERIAL. HOLOTYPE (QMT108580) ♂: NEQ: 17°26'S, 145°42'E, Hughes Rd, Topaz, 6 Dec 1993-25 Feb 1994, Monteith, Cook, Janetzki, RF Intercept, 650m. PARATYPES (11): 8 ex.: same data as holotype; 1 ex.: NEQ: 17°14'S 145°25'E, 3km W of Bones Knob, 10.xii.1995-9.ii.1996, GM,DC,GT, RF PT, 1140m; 1 ex.: Qld: 17.37S,145.34E 1000m, BS3 Massey Ck., 1.xii.1994-3.i.1995, PZ, FIT JCU (West); 1 ex.: Qld: 17.28S 145.29E, BS1 Longlands Gap, 2.x-1.xi.1995, LU, 1150m, FIT JCU, in QMB, DPIM, ANIC, MSCC.

DIAGNOSIS. The surface texture is unique among members of the *pygidialis* group. Both sexes have shiny, only very shallowly punctatostrigose elytra. In the females, apart from the humeri and epipleurae, the elytra may be entirely impunctate.

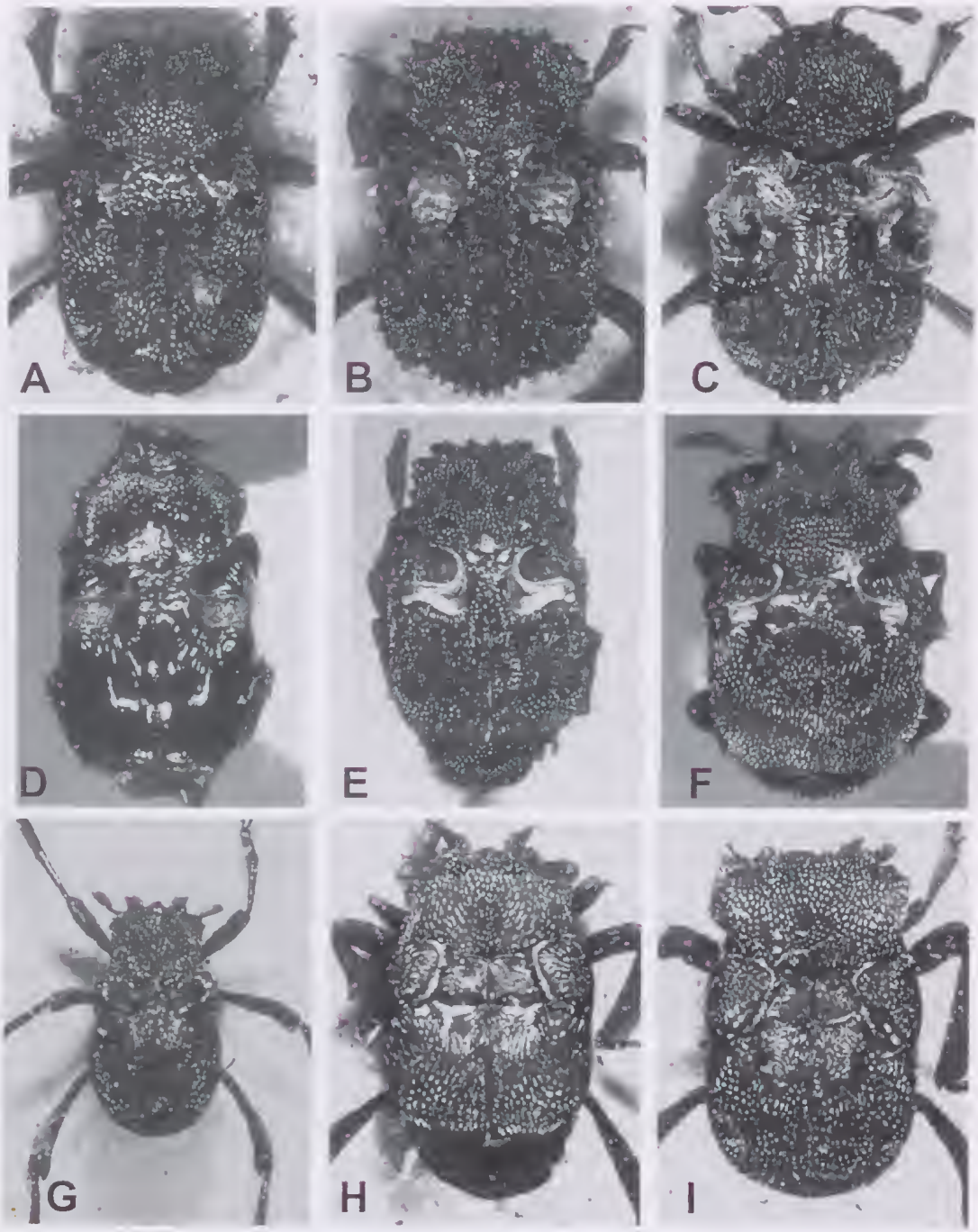

FIG. 7. Dorsal views of *Chlamydopsis* spp. A, *C. carinicollis*. B, *C. serricollis*. C, *C. sctipennis*. D, *C. convergens*. E, *C. erupta*. F, *C. transversa*. G, *C. longipes*. H, *C. inaequalis*. I, *C. agilis*.

The males typically have sparse shallow punctures on the dorsal elytral apices as well. The pronotum may also be largely impunctate, although it is more variable in this regard than the elytra. An additional, almost unique feature is a secondary erect fringe of setae above the

decumbent fringe along the anterior inner edge of the trichome. This is seen in one of two individuals of *C. coronis* as well.

DESCRIPTION. L: 1.87; W: 0.69; E/Pn L: 1.73; E/Pn W: 1.10; Pn W/L: 1.77; E L/W: 0.88; Pr/Py: 1.14; Sterna: 0.59, 0.16, 0.53; Tibiae: 0.69, 0.75, 0.90. Body nearly black, faintly rufescent (especially extremities) parallel-sided. Frons as wide as long, sides rounded, disk with 6 prominent tubercles arranged in two vertical rows, the middle pair most prominent, the upper pair least, the anterior pair on the apical margin; frontal disk with slightly irregularly spaced rounded punctures; labrum rounded, with a few small punctures, about 6 inconspicuous setae on apical margin; antennal scapes arcuate, with outer margin somwhat undulating, obliquely truncate apically, anterior surface convex, subcarinate along the longitudinal axis.

Pronotum margined laterally, convex, with a small acute tubercle medially, concave behind upturned lateral and anterior margins; lateral margins outwardly arcuate and widening slightly towards the front, continuous with inwardly arcuate, oblique anterior margins; middle third of anterior margin somewhat separated from lateral oblique portions, its edge slightly interrupted at middle; median pronotal elevation extended anteriorly as a faint carina; pronotal disk densely puncate in anterior and lateral depressions, less so on medial convex area; posterior edge of pronotal disk with a fine, distinct marginal stria.

Prosternum with anterior margin faintly sinuate, not grooved, transversely depressed behind anterior margin, rising slightly to narrowed posterior apex of prosternal keel, which is faintly tuberculate at middle, acutely emarginate apically, with circumcoxal stria carinate; prosternal disk uniformly punctate, with strong microsculpture between punctures.

Mesosternum about 2× as wide as long, acutely projecting at middle, with complete anterior marginal stria, punctate as prosternum, raised slightly above anterior margin of metasternum; metasternal disk with coarse punctures along anterior margin, more finely but uniformly punctate elsewhere; abdominal sternite 1 similarly punctate anteriorly, but more finely behind.

Elytra with humeral trichomes well developed, strongly depressed between, coarsely rugose in anterior (except along elytral suture), smoother, with shallow punctures posteriorly (and extending faintly anteriorly along suture) in male, more or less impunctate in most females; trichome basically a transverse incision between anterior and posterior elevations, with dense setal fringe extending inwardly and ventrally from apex, curving anteriorly along inner basal edge where it meets the inconspicuous, horizontal anterior superficial groove; each elytron with a poorly developed transverse carina in outer half, about one-third from apex; posterolateral marginal carina from elytral apex (well developed in, e.g., *C. transversa* sp. nov.) faint, confined to apical corner; epipleurae with shallow striae converging to apex of trichome.

Outer surfaces of protibia and femur uniformly covered with shallow punctures, those of meso- and metathoracic legs with only very fine punctures; protibiae slender, angulate at middle of outer edge, with margins arcuate to angle; meso- and metatibiae much broader, though still more or less angulate, their inner edges with discrete band of microsculpture where they overlap the inner edge of femora; the tarsal grooves of meso- and metatibiae parallel to the apical half of lateral margin (rather than parallel to the longitudinal axis of the tibia).

Propygidium depressed along basal margin, but strongly transversely carinate along apical margin, this carina weakly interrupted at middle, with an additional median tubercle just anterior to the carina, uniformly punctate with punctures separated by slightly less than their widths; pygidium weakly convex at middle, flat to weakly depressed along apical margins, punctures smaller and more widely separated than those of propygidium, almost uniformly distributed, only slightly denser in anterior corners.

REMARKS. A single male specimen from Qld: 2km SE Mt Spurgeon (QMB) has a particularly well developed median pronotal tubercle, and conspicuous posterolateral pronotal tubercles, which are only faintly detectable in the type series of *C. convergens*. Its pronotal punctation is also distinctly coarser. This specimen is excluded from the type series. However, a subspecies designation might be appropriate if additional material from this area shares these differences. The name of this species refers to the convergently strigose sculpturing of its epipleurae.

Chlamydopsis coronis sp. nov.
(Fig. 9)

MATERIAL. HOLOTYPE (QMT108581) ♀: 3km N. Lansdowne via Taree, N.S.W., 10 Feb.1988, G. Williams, intercept trap; ex rainforest-wet scler. forest margin.

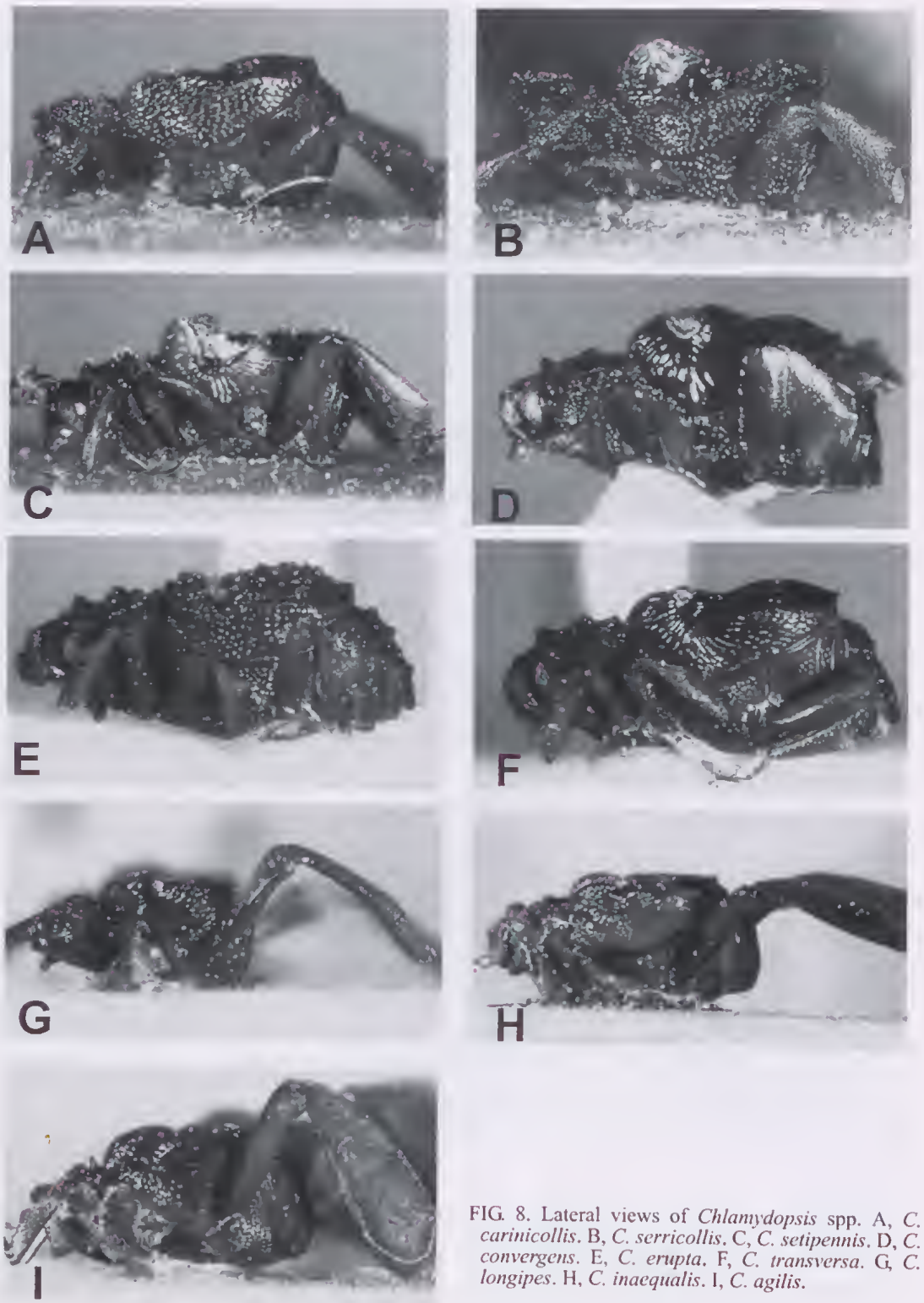

FIG. 8. Lateral views of *Chlamydopsis* spp. A, *C. carinicollis*. B, *C. serricollis*. C, *C. setipennis*. D, *C. convergens*. E, *C. erupta*. F, *C. transversa*. G, *C. longipes*. H, *C. inaequalis*. I, *C. agilis*.

DESCRIPTION. L: 2.18; W: 0.78; E/Pn L: 1.80; E/Pn W: 1.30; Pn W/L: 1.60; E L/W: 0.87; Pr/Py: 1.13; Sterna: 0.65, 0.22, 0.62; Tibiae: 0.69, 0.84, 1.00. This species is extremely similar, and closely related, to the preceding species. Only the differences are described here. Pronotum with transverse row of 4 median tubercles, with a carina running from the base of the middle two to the anterior marginal ridge, with which it merges; with a pair of posterolateral tubercles on each side, and with a low but distinct pair of posteromedial tubercles immediately in front of scutellum; lateral pronotal margin slightly undulating, widening slightly towards front, entire pronotal disk densely and uniformly punctate. Elytra with trichome similar in shape, posterior transverse carina of elytron developed as a row of three tubercles, the middle the most prominent; row of tubercles present from elytral apex anteriorly along elytral suture, diminishing in prominence towards the front, detectable to about the elytral midpoint; apical margin of elytron carinate and prominent, particularly in about the middle third. Punctures of posterior portion of metasternum slightly larger than in *C. convergens*. Propygidium with apical transverse carina interrupted to form row of 5 tubercles, with an additional medial tubercle anterior to this row; pygidium with faintly developed medial tubercle at basal one-third.

REMARKS. A second specimen, probably of this species (ACT: Blundells Ck, 3km E of Piccadilly Circus; ANIC), is not included in the type series due to several differences. Most obviously the pronotal tubercles are much less prominent and the secondary, erect row of trichome setae is not present. Additional material from these and intervening (they are separated by about 700km) localities needs to be studied to determine the significance of these differences. The name of this species refers to the crown-like appearance of the anterior pronotal margin.

Chlamydopsis erupta sp. nov.
(Figs 7E, 8E, 9)

MATERIAL. HOLOTYPE (QMT108582): NEQ: 17°26'S, 145°42'E, Hughes Road, Topaz, 6 Dec 1993-25 Feb 1994, Monteith, Cook, Janetzki, RF Intercept, 650m. PARATYPES (21): 4 ex.: same data as holotype; 1 ex: NEQ, 19km NE of Mareeba, 20.xii.1984-7.i.1985, RS & Titmarsh/MDPI Site 26; 2 ex.: NEQ, Windsor Tableland, 28.ii-6.iii.1992, JH, FIT; 1 ex.: Qld, 17.28S 145.29E, BS1 Longlands Gap, 30.xi.1995-3.i.1996, LU, 1150m, FIT JCU; 1 ex.: NEQ, Hugh Nelson Range, 21kmS Atherton, 1.xii.1983-9.i.1984, RS & JB/MDPI Site 17; 1 ex.: NEQ, Millaa Millaa Falls, 13.iii-10.iv.1990,RS & KH, MDPI FIT Site 34; 2 ex.: same but 7.ii-13.iii.1990; 1 ex.: same but 4.v-6.vi.1990; 2 ex.: NEQ, Wongabel SF, 6km S Atherton, 26.vii-3.ix.1984, RS & JB/MDPI Site 18; 1 ex.: same but 3.ix-1.xi.1984; 2 ex.: NEQ, Charmillin Ck Xing, 950m, Tully Falls Rd, 8.xii.1989-5.i.1990, GM,GT,HJ, PT&FIT; 1 ex.: Qld, 17.06S 145.37E, Mt Edith GS2,1050m, 17.iii-6.iv.1995,PZ, FIT; 1 ex.: NEQ, 6km S Kuranda, 15.i-20.ii.1985, RS & KH, MDPI Site 22; 1 ex.: Qld, 17.33S 145.32E, BS2, Mt Fisher, 1150m, 3.x-2.xi.1995, LU, MT, in QMB, DPIM, ANIC, MSCC.

DIAGNOSIS. While this species shows a couple of obvious similarities to the preceding, in particular the transverse row of 4 median pronotal tubercles and the row of tubercles along the posterior half of the elytral suture, it is otherwise one of the most distinctive of all *Chlamydopsis*, with the entire dorsal surface tuberculate. Most tubercles on the elytra, especially those on the anterior surface of the humeral trichome, are without obvious homologues in any other species.

DESCRIPTION. L: 1.81; W: 0.69; E/Pn L: 1.64; E/Pn W: 1.35; Pn W/L: 1.41; E L/W: 0.86; Pr/Py: 1.08; Sterna: 0.50, 0.12, 0.44; Tibiae: 0.56, 0.65, 0.75. Body dark rufescent in color, with conspicuous tubercles on most dorsal surfaces, more or less reticulately punctate throughout. Frons slightly longer than wide, sides (below antennal insertions) nearly straight, slightly convergent to apex, surface with two longitudinal rows of 3 tubercles each (in most individuals; specimens with only 2 or as many as 4 tubercles in each row have been seen), the anteriormost pair at the apical margin, the uppermost row between the antennal insertions; frontal surface otherwise reticulately punctate; clypeolabral suture slightly incurved; labrum rounded, shallowly punctate; antennal scape arcuate, widest at middle, outer edge undulating, surface texture as on frons with from 2-3 tubercles in a longitudinal row; antennal club of male slightly longer than scape, that of female about 2/3 as long as scape.

Pronotum about twice as wide as long, sides margined, more or less inwardly arcuate, interrupted by subbasal and, usually, subapical tubercles; anterior margin strongly upturned, with lateral supra-antennal portions arcuate and separated from medial portion, the medial portion sinuate, often forming a continuous 'Y' with a longitudinal carina in the anterior third of disk, some individuals with anterior marginal carina isolated and only a medial anterior tubercle; medial portion of disk with numerous tubercles, somewhat varied in specific arrangement,

usually with a transverse arcuate row of 4 at middle, a pair on each side posterolateral to this row, and a prominent pair in front of the scutellum, in addition to those along the lateral margins; often also tubercles between scutellar pair and transverse median row; ground texture uniformly densely punctate; posterior margin of pronotum with fine marginal stria, this interrupted at a small prescutellar emargination.

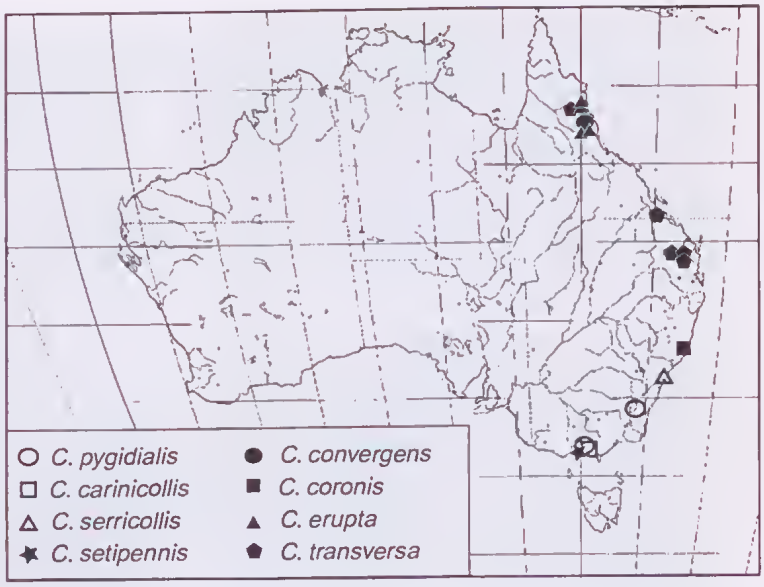

FIG. 9. Collecting records for species of *Chlamydopsis pygidialis* group.

Anterior margin of prosternum simple, middle third weakly outwardly arcuate, prosternal disk transversely depressed behind anterior margin, an isolated transverse stria visible in some individuals in this depression, prosternal keel with tubercle at middle, narrowed posteriorly, acutely emarginate at apex, with circumcoxal stria carinate, separating smooth leg cavities from reticulate prosternal disk.

Mesosternum slightly more than 2 × as wide as long, acutely projecting anteriorly, without an obvious marginal stria, subcarinate along midline and raised in posterolateral corners, elsewhere depressed, coarsely punctured and microsculptured throughout; mesometasternal suture finely but distinctly impressed; metasternal disk coarsely punctured and microsculptured throughout, but punctures smaller and sparser at middle; 1st visible abdominal sternite with a continuous row of punctures along anterior margin, elsewhere more sparsely punctate, with conspicuous microsculpture throughout.

Elytra parallel sided, rather abruptly narrowed at base and apex, tuberculate throughout, most consistently along elytral suture (the anteriormost of these less prominent), at sides immediately behind trichomes, and on the dorsum of the anterior elevation of the trichome; humeral trichome well developed, though not as strongly elevated as in most species of this group, forming a sinuate transverse groove, widening at middle, curved anteriorly to base of elytron, continued anterolaterally by a fine, oblique anterior superficial groove; trichome densely lined on inner edges by inclinate golden setae which completely obscure its opening; surface of elytra mostly reticulately punctate, with reticulae more elongate posteromedial to trichomes; posterior marginal carina well developed, and undulating, particularly at the centre, extending forward at side (where it diverges from the elytral margin) approximately one-fifth of the distance from apex.

Legs as in *C. convergens*, except outer surfaces of meso- and metathoracic legs slightly more densely punctate, though still less so than prothoracic legs.

Propygidium depressed along basal margin, elevated as a transverse row of tubercles along apical margin, with prominent medial, and less prominent lateral, tubercles in front of this row; pygidium slightly convex, with three prominent tubercles in an arcuate row near base, and with slightly elongate tubercles at middle of each lateral margin; propygidium and pygidium densely punctate throughout.

REMARKS: A single specimen from near Lansdowne (NSW: Lorien, 4.i.1987; CMN) is excluded from the type series. This locality is over 1000km from the next nearest site for the species. Although its dorsal tubercles clearly associate it with this species, differences in metasternal punctation and trichome shape leave its specific identity uncertain. The name of this species refers to the numerous tubercles on its body.

Chlamydopsis transversa sp. nov.
(Figs 7F, 8F, 9)

MATERIAL. HOLOTYPE (QMTI08582) ♂: AUSTRALIA: N Qld, Hann Tableland, 13km WNW of Mareeba, 9.xi-7.xii.1988, Storey & Dickinson/ MDPI Intercept Trap Site No. 31. PARATYPES (22): 3 ex.: same data as holotype; 3 ex.: same but 17.ii-20.iii.1989; 1 ex.: same but 13.x-9.xi.1988; 2 ex.: same but 1.iii-12.iv.1994; 2 ex.: same but 7.xii.1988-17.i.1989; 2 ex.: same but 13.i-1.iii.1994; 1 ex.: same but 13.vii-4.viii.1988; 1 ex.: same but 4.viii-9.ix.1988; 1 ex.: same but 20.vi-13.vii.1988; 1 ex.: SEQ: 26°16'S 151°25'E, Koy Property at Brigooda (Top site), 26.i-20.iv.1995, GM, FIT, vine scrub; 1 ex.: SEQ: 25°31'S 152°18'E, Fairlies Knob, 0.5km S, 21.vii-20.x.2000, 300m, DC, Wright, Vanderduys, vine scrub PT 9464; 1 ex.: SEQ: 25°08'S 151°59'E, Nangur SF, 2nd site, 24.xi.1995-3.ii.1996, GM, FIT, RF, 320m, 5853; 1 ex.: SEQ: 27°14'S 152°15'E, Mt Deongwar, 3km S, site 2, 30.xii.98-26.iii.1999, GM, RF PT, 460m, 7652; 1 ex.: SEQ: 25°40'S 151°26'E, Nipping Gully, site 2, 21.viii-9.x.1998, GM, RF FIT, 200m, 7258; 1 ex.: Qld, 23°37'S 150°28'E, Mt Gavial, 3km SSW, 18.xii.98-14.iii.1999, DC, vine forest FIT, 320m, 7492, in QMB, DPIM, ANIC, MSCC.

DIAGNOSIS. This species is easily recognised by the combination of well developed transverse medial and posterolateral pronotal carinae, well developed subapical elytral carinae (in lateral half of each elytron), absent or at most weak median longitudinal pronotal carina, slender metatibia acutely angulate at its midpoint, and elytra densely reticulopunctate (except in mediobasal depression) in both sexes.

DESCRIPTION. L: 1.90; W: 0.69; E/Pn L: 1.77; E/Pn W: 1.26; Pn W/L: 1.59; E L/W: 0.89; Pr/Py: 1.14; Sterna: 0.56, 0.16, 0.47; Tibiae: 0.75, 0.78, 0.97. Dark rufescent brown, elongate, parallel-sided, near entire dorsum densely reticulately punctured. Frons nearly as wide as long, sides rounded, disk deeply reticulately punctate, with 6 prominent, more or less acute, tubercles arranged in two vertical rows of 3, the middle pair the most prominent; frontal punctures as elsewhere (e.g., antennal scapes, pronotum); labrum arcuate, semicircular, with two long and several short setae; antennal scapes with outer edges irregularly arcuate, widest at middle, anterior surface convex and reticulately punctured; antennal club of male very elongate, approximately 1.25× as long as scape.

Pronotum about 1.3× as wide as long, margined laterally, sides more or less inwardly arcuate, but interrupted at basal one-third by a low acute tubercle; anterior pronotal margin strongly upturned, obliquely arcuate above antennal cavities, these edges discontinuous from medial portion of margin, which is bilobate, the two halves meeting in a very shallow 'V'; pronotal disk with a strong transverse carina in medial one-third, rising about equally high as the upturned anterior pronotal margin, the dorsal edge of this carina weakly sinuate, and with additional lateral tubercles immediately posterolaterally, these adjacent to, but not continuous with those along the lateral pronotal margins; pronotal disk also with relatively small tubercles along posterior margin, immediately in front of and on each side of the scutellum.

Prosternum with anterior margin faintly sinuate, not grooved, transversely depressed behind anterior margin, rising slightly to narrowed posterior apex of prosternal keel; prosternal keel acutely emarginate apically, with circumcoxal stria carinate; prosternal disk densely punctate.

Elytra parallel-sided, with prominent humeral trichomes, the anterior elevations of which are strongly convex, with complete marginal fringe of conspicuous golden setae from inner base to apex, apparently continuous, through a shallow lateral groove, with the anteriorly directed setae of the apex of the posterior elevation; anterior superficial groove inconspicuous but entering the trichome horizontally at the inner base; each elytron with an isolated transverse carina in lateral half, one-fourth from the apex, and a lateral longitudinal carina, continuous with the posterior elytral margin, delimiting the epipleuron in the apical half; elytral disks reticulately strigose basally and laterally (especially on epipleuron), becoming more finely reticulate at middle and towards apex.

Mesosternum acutely projecting at middle, slightly raised at middle and along posterior margin, with complete anterior marginal stria, densely punctate and microsculptured; metasternal disk more finely and sparsely punctate than mesosternum, especially laterally; visible abdominal sternite 1 densely punctate along basal margin and at sides, less densely posteriorly.

Prothoracic legs slender, reticulately punctate, the protibia acutely angulate one-third from base; meso- and metathoracic legs slightly more elongate, and less conspicuously punctured, although with microsculpture, both posterior tibiae similarly angulate to protibia.

Propygidium depressed along basal margin, but strongly transversely carinate along apical margin, this carina weakly interrupted at middle,

with an additional median tubercle anterad; pygidium weakly convex at middle, weakly depressed along apical margins, and with a median tubercle one-third from basal margin; both propygidium and pygidium uniformly reticulately punctate.

REMARKS. The name of this species refers to the transverse pronotal carina.

LONGIPES GROUP

The *longipes* group is clearly monophyletic, with three known species. In addition to the extremely elongate metatibiae, the species all share: prominent pyramidal frontal protuberance, elongate arcuate labrum, curved humeral trichome with the anterior superficial stria entering at the mesal base, and clavate metafemora. Of these, all are probable synapomorphies except for the trichome character, which resembles the possibly related *pygidialis* and *striatipennis* groups.

Chlamydopsis longipes Lea, 1910
(Figs 7G, 8G, 12)

Chlamydopsis longipes Lea, 1910: 201; Type locality: Vic: Bannockburn; repository: SAM; not examined.

RECORDS. SAM: SA: Katarapko Game Res. 34°24'S, 140°34'E, pitfalls, 9-26 May, 1991. NHM: Vic: Melton, x.1920. WAM: Vic: Melton. Lea (1912): Vic: Ararat. Oke (1923): Vic: Melton; Vic: Bacchus Marsh.

DIAGNOSIS. Despite sharing the basic trichome plan with the other two species of this group, its actual shape in *C. longipes* is highly distinctive. The inner edge is deeply and broadly emarginate, the humerus consequently appearing as a thin, inwardly open arch. This species also has the most elongate meso- and metatibae of the three, as well as a generally more elongate body, particularly noticeable in the form of the pronotum.

Chlamydopsis inaequalis Blackburn, 1891
(Figs 7H, 8H, 12, 29C)

Chlamydopsis inaequalis Blackburn, 1891: 94; Type: Australia, NHM; examined, 2000.

RECORDS. ANIC: ACT: 35.17S 149.07E, Black Mt, 4.i.1989, light trap (1); 4 others, same locality, all from light traps, Jan. (3), Feb. (1).

DIAGNOSIS. L: 2.93; W: 1.06; E/Pn L: 1.76; E/Pn W: 1.31; Pn W/L: 1.53; E L/W: 0.88; Pr/Py: 1.10; Sterna: 1.00, 0.19, 1.12; Tibiae: 1.25, 1.62, 2.49. This species and *C. agilis* are very similar in body form, both being much more quadrate than *C. longipes*, and their trichome shape is essentially identical. The two may be separated by the form of the metatibia, which in *C. inaequalis* is much more slender, with the subapical angulation about one-third from the apex. In *C. agilis* the angulation is less prominent, and nearer one-sixth from the apex.

Chlamydopsis agilis Lea, 1914
(Figs 7I, 8I, 12)

Chlamydopsis agilis Lea, 1914b: 216; Type locality: NSW: Sydney; repository: SAM; not examined.

RECORDS. NHM: NSW: Sydney (Det. by Lea). Lea (1919): SA: Naime, nest *of Ectatomma metallicum*. Lea (1925): NSW: Como; NSW: Lane Cove.

DIAGNOSIS. See above under *C. inaequalis*.

REMARKS. The type was collected from a nest of *Ectatomma metallicum* (Lea, 1914b).

ECTATOMMAE GROUP

The *C. ectatommae* group is primarily defined by a short anterolateral pronotal groove that originates along the upper edge of the antennal cavity, extends posterolaterally, incising the lateral portion of the anterior pronotal margin, curves around the lateral pronotal margin (which in most of these species is poorly defined), and then merges with the lateralmost extent of the circumcoxal stria. In all but a couple of species this groove is very distinct. Where it appears only weakly impressed (*C. pecki* sp. nov., *C. mallee* sp. nov.), additional similarities to other species leave little doubt as to their placement. The *bifovaecollis* subgroup is placed here with some uncertainty. These are unique in having a pronotal groove, originating at the same point behind the antennal cavities, that extends straight backward and ends in a conspicuous dorsolateral pit (Fig. 29A) In addition to this putatively homologous groove, the trichome shape is quite similar to that of several other unquestioned members of the *ectatommae* group. That said, trichome shape is rather varied across the entire *ectatommae* group. In most species the anterior and posterior elevations converge to a single apex, are uninterrupted laterally, and have a mesal emargination fringed with a simple arc of setae, concealing the trichome opening beneath. The anterior superficial groove of the trichome usually extends somewhat inwardly and obliquely from the humeral corner to the anteromesal origin of the setal fringe. The major variables are the height of the trichome and the size of the mesal emargination (and consequently the extent of the setal fringe.) One extreme is

found in *C. loculosa*, in which the trichome constitutes no more than a small humeral pit at the apex of the anterior superficial groove. Unlike species in the preceding groups, but like most of those that follow, the *ectatommae* group species have the anterior prosternal margin deeply grooved, with the groove diverging from the margin laterally to meet the circumcoxal stria.

This is a large group, containing more than 20 known species, ranging across temperate and tropical Australia, and with two members occurring in New Guinea (*C. papuae* Lewis and *C. jayawijaya* sp. nov.).

Chlamydopsis ectatommae Lea, 1912
(Figs 10A, 11A, 12)

Chlamydopsis ectatommae Lea, 1912: 66; Lectotype, hereby designated: *ectatommae* Lea Type, Gladesville / cotype [on underside of same label]/ 14671, *Chlamydopsis ectatommae* Lea N. S. Wales, Type; SAM, examined 2002. It is uncertain whether syntypes of this species exist in other collections, as the 'cotype' label would imply. The 'cotype' written on the bottom of the main label is partially cut off, and may not have been intended to pertain to this specimen.

Chlamydopsis ectatommae var. *rufomaculatus* Oke, 1923: 153; Mazur, 1984; Type: Victoria: Melton; Bacchus Marsh, in nests of *Chalcoponera metallica*; SAM, not examined.

RECORDS. NHM: NSW: Como; NSW: Sydney (Det. A. Lea). WAM: NSW: Cooma, v.1935. ANIC: ACT: 35.16S 149.06E, Black Mt 600m, Mar. (sweeping), Oct. (FIT); SA: 34.21S, 139.31E, Brookfield Con.Pk, x-xi.1992, FIT (2). Lea (1918): NSW: Hunters Hill, 30.v.1917. Lea (1925): Vic: Lakes Entrance, October; SA: Mount Lofty Range, May. Oke (1923): Vic: Bacchus Marsh, *Chalcoponera metallica*.

DIAGNOSIS. L: 1.87; W: 0.75; E/Pn L: 1.50; E/Pn W: 1.31; Pn W/L: 1.33; E L/W: 0.86; Pr/Py: 1.00; Sterna: 0.56, 0.12, 0.56; Tibiae: 0.69, 0.69, 0.75. *Chlamydopsis ectatommae*, *C. kununurra* sp. nov., and *C. acutricha* sp. nov. are all very similar in the shape of their humeral trichome and are diagnosed together here. In all of these the apex of the trichome is subacute, projecting slightly above the middle of the inner setal fringe, and bears a few dorsally or mesally directed setae, which are separate from the inner are. This projection and a small area around its base are distinctly smoother than the surrounding integument. (The only other known species that has a similar form of trichome is *C. myrmecophila* sp. nov., in which the apex is only barely or not at all projecting, and the lateral surface of the trichome is deeply vertically furrowed). *Chlamydopsis acutricha* is the smallest of these three (1.62mm), has a median pronotal tubercle which is blunt rather than distinctly acute, has the elytra nearly smooth behind the trichomes rather than coarsely reticulo-punctate throughout, and has the metasternal disk entirely impunctate. *Chlamydopsis ectatommae* and *C. kununurra* are more similar, differing primarily in pronotal shape. In *C. kununurra* the median pronotal tubercle is more strongly elevated and acute, the medial portion of the anterior pronotal margin is more distinctly elevated, shallow oblique furrows extend anterolaterally from the scutellum, and the pronotal reticulae, particularly along the anterior margin, are more distinctly elongate.

REMARKS. The type was reportedly collected in a nest of *Ectatomma metallicum* (Lea, 1912).

Chlamydopsis kununurra sp. nov.
(Figs 10B, 11B, 12, 28D)

MATERIAL. HOLOTYPE (QMT108584) ♂: N WA, Kununurra, 22.XII.1991-5.I.1992, R.I. Storey.

DIAGNOSIS. See diagnosis above under *C. ectatommae*.

DESCRIPTION. L: 1.93; W: 0.72; E/Pn L: 1.70; E/Pn W: 1.31; Pn W/L: 1.52; E L/W: 0.85; Pr/Py: 0.94; Sterna: 0.56, 0.16, 0.56; Tibiae: 0.81, 0.75, 0.84. Body subquadrate, rufescent (the type is likely teneral), dorsal surfaces mostly reticulo-strigose; Frons with sides rounded, disk reticulopunctate, with sparse elongate setae; labrum rounded; antennal scape widest at basal one-third, abruptly narrowed to base, distal margin straight, narrowed to rounded apex, reticulate and setose as frons; antennal club of male 1.25 × length of scape.

Prothorax 1.5 × as wide as long, sides uneven, wide near base, bluntly projecting, narrowed in anterior half, wider, subacute in front of anterolateral groove; medial portion of anterior margin weakly elevated, notched at middle, separated from lateral portions; lateral portions more strongly elevated, arcuate, ending laterally where intersected by well developed antero-lateral groove; pronotal disk depressed behind anterior margin, more broadly so at sides, elevated and acute at middle, posterolateral corners convex, separated from medial elevation by shallow, oblique antescutellar furrows; disk entirely reticulopunctate, reticulae varied in size, generally elongate, diverging around median tubercle.

Anterior prosternal margin grooved, sinuate, projecting on either side of middle; prosternal

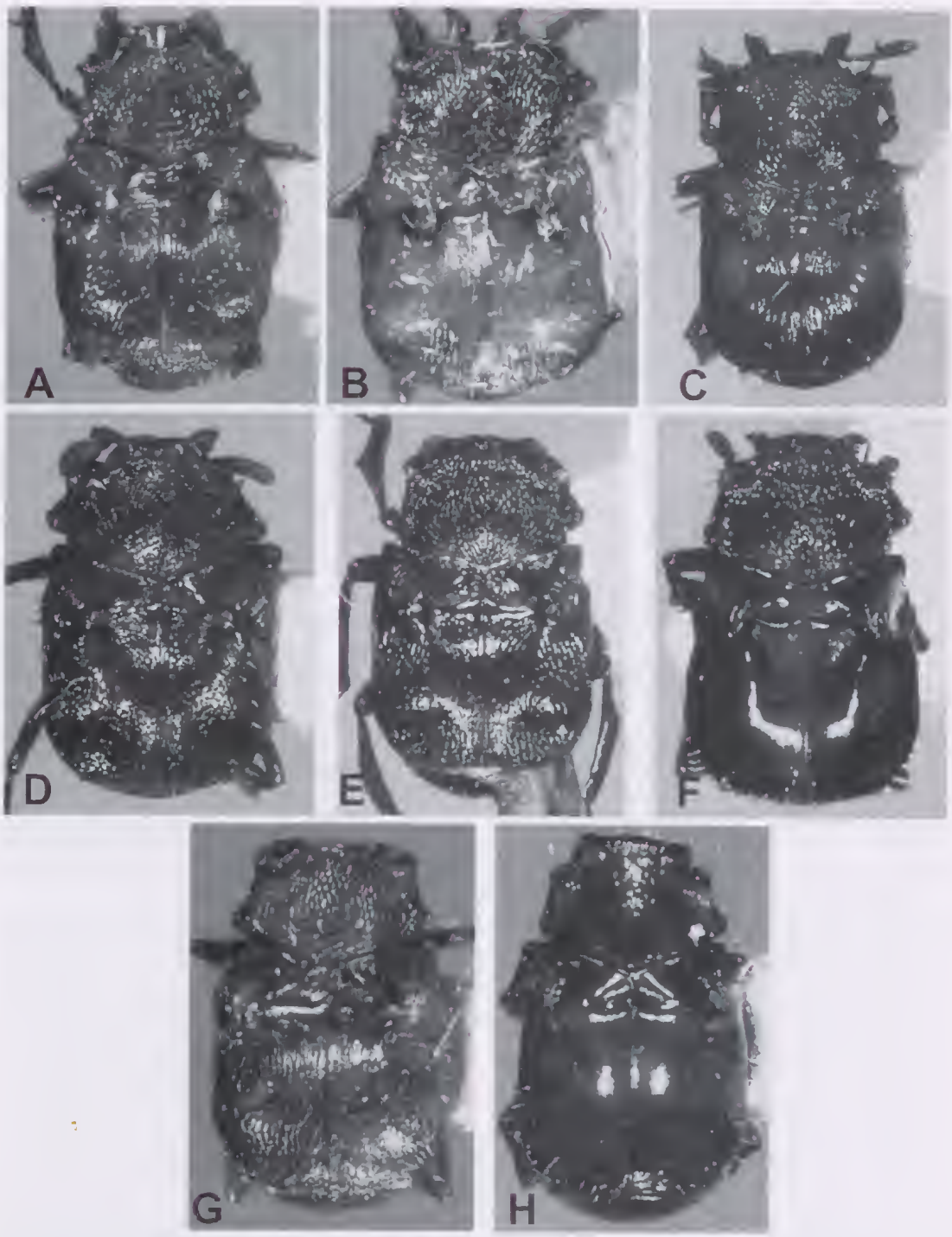

FIG. 10. Dorsal views of *Chlamydopsis* spp. A, *C. ectatommae*. B, *C. kununurra*. C, *C. acutricha*. D, *C. myrmecophila*. E, *C. variolosa* (♂). F, *C. variolosa* (♀). G, *C. mallee* (♂). H, *C. mallee* (♀).

disk slightly depressed behind anterior margin, entirely reticulopunctate, narrowed posteriorly, acutely emarginate at apex.

Elytra about one-fifth wider than pronotum, parallel-sided, narrowed to base and apex; humeral trichomes small, closed laterally, open mesally with an arc of mesoventrally directed setae, with an acute peak above, the inner surface of this peak with a separate cluster of mesally directed setae, its outer surface smooth; anterior superficial groove oblique, extending from humeral corner to inner base of opening of trichome; mediobasal depression with transverse, arcuate carinae; elytral disk reticulostrigose; apical elytral margin subcarinate, with elongate setae (some setae in 'bundles'); elytral disk otherwise very sparsely setose.

Mesosternum about 4× as wide as median length, projecting at middle, densely punctate, crenulately so along posterior margin; meso-metasternal suture impressed, metasternal disk with large punctures behind suture and at sides, with only few small punctures at middle; 1st visible abdominal sternite with continuous row of large punctures separated by about their widths along anterior margin and inner postcoxal stria, more sparsely punctate behind.

Legs generally slender, profemur and tibia punctate on outer surfaces, meso- and metafemora and tibiae less so; protibia acutely angulate one-third from base, meso- and metatibiae bluntly angulate.

REMARKS. The name of this species refers to the type locality.

Chlamydopsis acutricha sp. nov.
(Figs 10C, 11C, 12)

MATERIAL. HOLOTYPE ♀: 12.40S 142.39E Qld, 3km W Batavia Downs, 23 Aug - 16 Sep 1992, Flight Intercept Trap, P.Zborowski & L.Miller; in ANIC.

DIAGNOSIS. See above under *C. ectatommae*.

DESCRIPTION. L: 1.62; W: 0.69; E/Pn L: 1.36; E/Pn W: 1.19; Pn W/L: 1.23; E L/W: 0.94; Pr/Py: 1.00; Sterna: 0.44, 0.09, 0.47; Tibiae: 0.56, 0.50, 0.62. Body rufescent, elongate, nearly parallel sided; frons about as wide as long, sides rounded, disk reticulate and with a few elongate setae; labrum short, rounded, reticulate; antennal scapes widest just beyond basal one-third, slightly narrowed to apex, more abruptly to base, surface reticulate and bearing 2-3 elongate setae; antennal club of female about three-fifths length of scape.

Prothorax about one-fourth wider than long; sides weakly margined near base; anterior margin distinctly but not strongly raised above antennal cavities, interrupted by a groove extending posterolaterally from edge of antennal fossa to circumcoxal stria; medial portion of anterior margin more or less flat; anterior and lateral margins with a few elongate setae; pronotal disk shallowly depressed in anterior corners, otherwise strongly and uniformly convex; disk rather shallowly reticulately punctured, with sparse mostly deeply bifid setae.

Prosternum with anterior margin sinuate, strongly grooved, this groove continuous with circumcoxal stria; prosternal keel narrowed posteriorly, emarginate at apex, prosternal disk mostly densely punctate, with small impunctate spaces medially.

Elytra about one-fifth wider than pronotum, parallel sided, narrowed to base and apex; convex in posterior two-thirds, depressed basally; humeral trichome small, shallowly furrowed laterally, open mesally with a fringe of ventrally directed setae, with an acute peak above, the inner surface of this peak with a separate cluster of mesally directed setae; superficial groove of anterior elevation curved, mostly horizontal, curving from anterior elytral corner to inner base of trichome opening; elytral disk shallowly reticulostrigose, mostly smooth in a longitudinal band behind trichome; apical elytral margin with elongate setae (some setae in 'bundles'), a few of these extending up the apical half of the elytral suture, elytral disk otherwise almost entirely glabrous.

Mesosternum acutely projecting anteriorly, punctate, elevated along mesometasternal suture; metasternal disk punctate along anterior margin, elsewhere entirely impunctate, very smooth; 1st visible abdominal sternite similarly punctate anteriorly (and with a few punctures laterally), impunctate behind.

Propygidium and pygidium of approximately equal length medially; propygidium flat along base, becoming strongly convex apically; pygidium weakly convex; both propygidium and pygidium with reticulate sculpture, that of pygidium fading in apical one-third.

REMARKS. The name of this species refers to the acute dorsal apex of the humeral trichome.

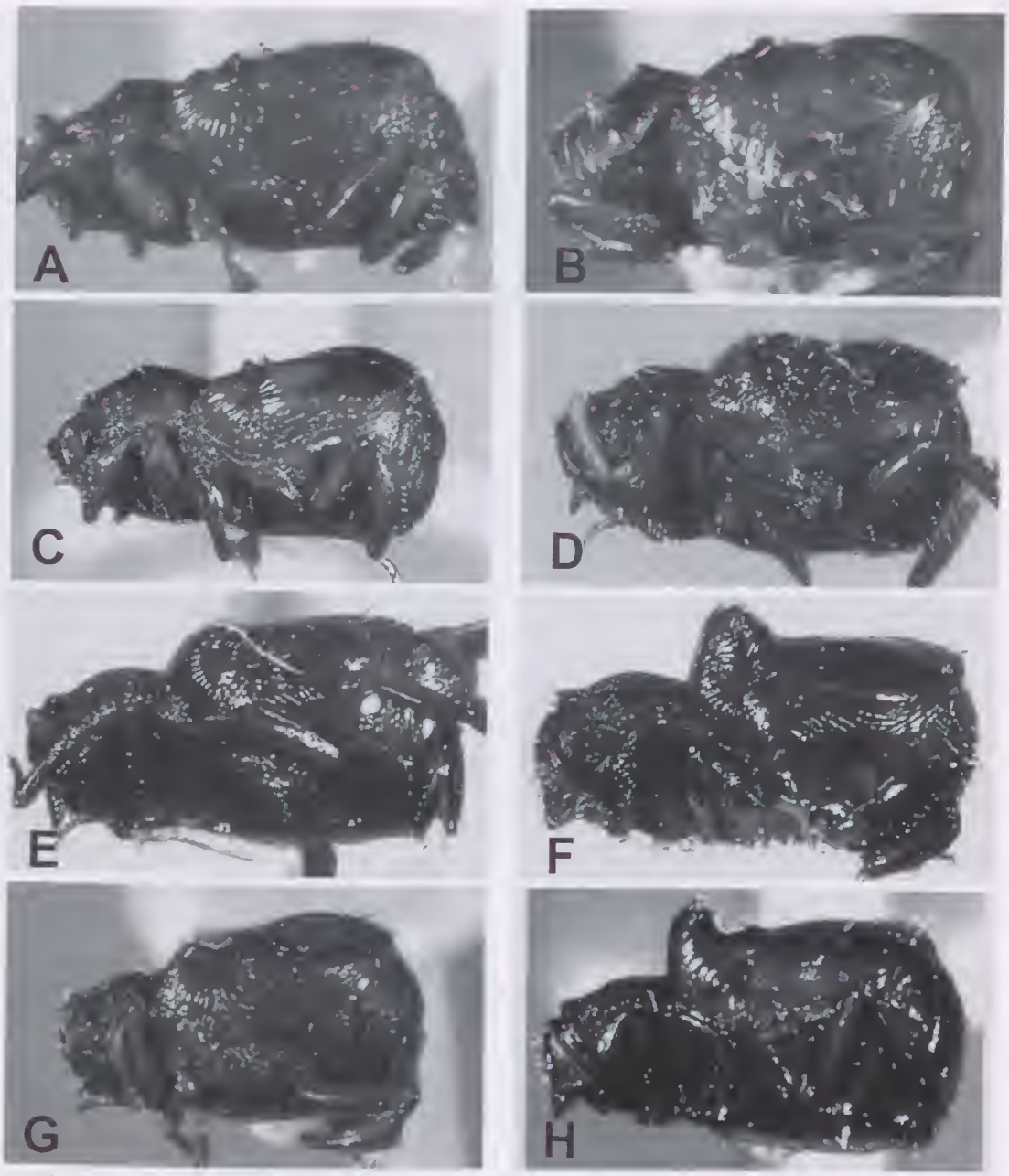

FIG. 11. Lateral views of *Chlamydopsis* spp. A, *C. ectatommae*. B, *C. kununurra*. C, *C. acutricha*. D, *C. myrmecophila*. E, *C. variolosa* (♂). F, *C. variolosa* (♀). G, *C. mallee* (♂). H, *C. mallee* (♀).

Chlamydopsis myrmecophila sp. nov.
(Figs 10D, 11D, 12, 29B)

MATERIAL. HOLOTYPE (QMT108585) ♂: Australia: N Qld, Hann Tableland, 13km WNW of Mareeba, 8.XII.1993-13.I.1994, R.Storey & S.DeFaveri, MDPI F.I.T.-site 31. PARATYPES (14): 4 ex.: same as holotype; 2 ex.: same but 13.i-1.iii.1994; 1 ex.: same but 5.xi-8.xii.1993; 1 ex.: same but 17.ii-20.iii.1989; 1 ex.: same but 9.xi-7.xii.1988; 2 ex.: same but 17.i-17.ii.1989; 2 ex.: NEQ: Evelyn, 21.xii.1965; 1 ex.: same locality 28.??.1967; in AMB, DPIM, ANIC, MSCC.

DIAGNOSIS. While this species is similar to the preceding three in that a separate setal bundle is present at the apex of the trichome above the mesal setal fringe, this setal bundle is not borne on a prominent elevated tubercle, as in the others. The lateral surface of its trichome is also unique in the *ectatommae* group, bearing a deep vertical furrow from the apex of the trichome nearly halfway down the epipleuron, expanding slightly ventrad. This is only an indentation, and not a lateral opening to the trichome. This species is uniquely setose, bearing rather sparse, but quite long setae on essentially all surfaces.

DESCRIPTION. L: 2.12; W: 0.81; E/Pn L: 1.62; E/Pn W: 1.29; Pn W/L: 1.46; E L/W: 0.86; Pr/Py: 1.06; Sterna: 0.62, 0.12, 0.59; Tibiae: 0.90, 0.87, 1.00. Body subquadrate, rufescent brown, the pronotum appearing very slightly darker than elytra, most surfaces reticulately sculptured, bearing sparse but conspicuous long setae.

Frons about as broad as long, sides and anterior margin slightly rounded, disk reticulate; labrum short, arcuate, reticulate, with 6-10 long setae; antennal scapes arcuate, about twice as long as median width, lateral margin abruptly expanded one-third from base, evenly arcuate distally, with a few long discal setae and a lateral fringe of shorter setae, surface reticulate; antennal club of female about 2/3 as long as scape, antennal club of male about 1.3× as long as scape.

Pronotum 1.6× as wide as long, sides margined, not raised, nearly straight and slightly convergent; anterior margin slightly inwardly arcuate at middle, oblique and inwardly arcuate laterally above antennal cavities, middle portion slightly reflexed, lateral portions more so; anterior pronotal margin with a continuous groove running laterally halfway along dorsal margin of antennal cavity, departing from margin posterolaterally, joining circumcoxal stria; pronotal disk uniformly convex, reticulately sculptured, bearing sparse conspicuous setae.

Prosternum about twice as wide as long; anterior margin slightly deflexed, sinuate, projecting on each side, deeply grooved, this groove departing from margin laterally, curving posteriorly and continuous carinate circumcoxal stria; prosternal keel narrowed posteriorly, acutely emarginate at apex; prosternal disk reticulately punctate and with elongate setae.

Elytra with sides nearly parallel, slightly sinuate beneath trichomes; trichomes strongly produced dorsally, appearing transversely 'pinched', anterior and posterior elevations meeting narrowly at apex, deeply impressed laterally, mesally excavate and lined with ventromesally directed setae; anterior elevation of trichome with oblique superficial groove from anterolateral corner of elytron to inner apex of trichome; elytra broadly transversely depressed between trichomes; elytral disks mostly uniformly reticulate, the reticulae between the trichomes transverse; marginal stria of elytra complete except along basal half of elytral suture and on basal margin.

Mesosternum slightly more than twice as broad as long, acutely projecting anteromedially, reticulate, marginal stria not evident; meso-metasternal suture impressed; metasternal disk shallowly reticulopunctate in basal 1/5, laterally, and on lateral half of posterior margin between metacoxae, elsewhere smooth, with sparse elongate setae throughout; 1st abdominal sternite with row of shallow punctures along anterior margin, and sparsely scattered elsewhere.

All tibiae elongate, slender, angulate one-third from base; profemur and protibia shallowly reticulate, others smooth.

Propygidium 2/3 as long as wide, depressed along basal margin, convex elsewhere, uniformly reticulopunctate throughout; pygidium weakly convex, sparsely punctate in basal 1/3, otherwise smooth.

REMARKS. One of the paratypes offers a unique insight into the trichome functionality. It died in the death grip of an ant, presumably its host, with its mandibles eternally locked on the inner and outer furrows of the beetle's humeri. This ant (missing its gaster and one petiolar segment) appears to be an *Aphaenogaster*. Based on 'Australian Ants Online' (Shattuck & Barnett, 2001) two species of this genus are known to occur near the type locality of *C. myrmecophila*, *A. longiceps* Smith and *A. pythia* Forel. The former of these has previously been reported as host of *Chlamydopsis carinicollis* (Lea, 1919). The ant's position on the specimen tends to support Oke's (1923) contention that the humeral modifications were perhaps little more than handles for the hosts to carry the beetles around. The name of this species refers to its habits, this being one of the few new species where a host record confirms myrmecophily.

Chlamydopsis variolosa Lea, 1910
(Figs 10E-F, 11E-F, 15)

Chlamydopsis variolosa Lea, 1910: 206; Type: [illegible if Dalby, as published]/ 14169, *Chlamydopsis variolosa* Lea,

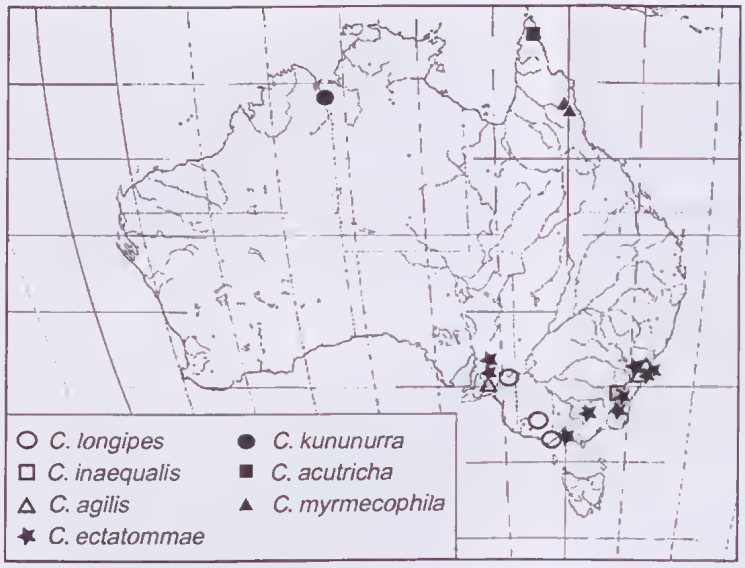

FIG. 12. Collecting records for species of *Chlamydopsis longipes* and *ectatommae* groups.

Queensland; SAM, examined, 2000; type locality: Dalby, Queensland [27°10'S,151°15'E].

Chlamydopsis atra Lea, 1914a: 250; Leetotype ♂, hereby designated: *atra* Type Lea Mt Tambourine/ T.1300 *Chlamydopsis atra* Lea Queensland, Type [in red]; SAM, examined. Paraleetotype ♂: same data as type; these two type speeimens are mounted side by side on a single eard. 'TY' had previously been written on the card behind the left-most specimen; this is the speeimen designated here as the Leetotype. New Synonymy.

MATERIAL. QMB: SEQ: 26°53'S 152°09'E, Benarkin Sehool, 14.xi.94-26.i.1995, GM, FIT, open forest [1 ♂, 1 ♀]; SEQ:25°13'S 149°01'E, Expedition Ra, Nat. Pk, 5729, 'Amphitheatre' yards, 440m, 19.xii.97-4.iii. 1998, DC & GM, open for. FIT. NHM: SEQ: Brisbane, Samford, 27.xii.1982. HAHC: SEQ: 27°19'54"S, 152°45'29"E, Mt Glorious, 26.xi.1997, MT. CMN: AUST: Qld, Mt Glorious, 630m, 28.ii-9.iii.1984, L.Masner,MT. Although also reported from northern Queensland (Lea, 1914a), it seems likely that this record should refer to one of the other species from that area described here. The specimen so referred to has not been seen.

DIAGNOSIS. L: 2.09; W: 0.75; E/Pn L: 1.79; E/Pn W: 1.38; Pn W/L: 1.42; E L/W: 0.91; Pr/Py: 1.19; Sterna: 0.56, 0.12, 0.62; Tibiae: 0.81, 0.84, 1.00. *Chlamydopsis variolosa*, *C. pecki* sp. nov., and *C. mallee* sp. nov. are a elosely related and morphologically similar trio of species. The most striking charaetcr uniting thcm is thc strong dimorphism in the sculpturing of the elytra, pronotum, and in the degree of development of the humeral triehomes. The putative males of all three have most of the body retieulostrigose, while the females are almost entirely smooth. The elytra and pygidia are the most distinct points of contrast between the sexes (and the frons and prosternum the least), but the difference is marked throughout. The triehomes of thc females are more strongly elevated dorsally, and in *C. mallee*, havc the inner edge of the trichomc more broadly (and acutely) emarginate. The females also have thc pronotum more distinetly margined laterally, resulting, in *C. pecki* and espeeially *C. mallee*, in thc near total obliteration of the charaeteristie anterolateral pronotal groove. Features shared by both sexes include rclatively small body sizc (<2.1mm), laek of median pronotal tubercle, deeply ineised anterior superficial humeral groove, transverse serics of setal bundles originating at the apex of the humeral triehome eontinued for a varied distanee down the lateral surface, and generally small trichome opening, the inner setal fringe of which originates from a short arc, but consists of elongate, ventrally directed setae, whieh largely eoneeal the inner opening of the trichomc (except in female of *C. mallee*). Most also have prominent setae on the frons, and along the pronotal and elytral margins (exeept in male of *C. mallee*). *Chlamydopsis variolosa* may be separated from the other two species by the very restricted origin of the inner trichome fringe. The arc spans a longitudinal distanee equivalent to about half the width of an antennal elub. The setae themselves projeet mesoventrally for a very short distanee, then bend ventrally, extending nearly to the floor of thc mcdiobasal elytral depression. In the other two speeies the originating arc of this fringc is morc extensivc, equivalent in length to at least an antennal width or greater. In the female of *C. variolosa* the anterior elevation of the triehome is more strongly elevated, projeeting well above the posterior elevation, and the pronotum is margined, although the anterolateral groove from the antennal eavity remains distinet.

REMARKS. Describing *C. atra*, Lea appears to have forgotten *C. variolosa* entirely. When diagnosing *atra* from similar species, *C. variolosa* is not even mentioned. The two type localities are separated by less than 200km in southeastern Queensland, and their synonymy appears clear. Lea (1914a) reported collecting the types of *C. atra* 'in January by means of the sweep net, used on low herbage, ferns, etc., late in the afternoon'.

The sexual dimorphism in this and the following two species requires additional study. Originally the putative females of *C. variolosa* and *C. pecki*, especially, had not even been considered members of this species group, due to the vague or absent anterolateral pronotal groove. At present, only single females are known for either of these two. Nonetheless, in all cases putative males and females have been collected at identical localities and trap dates, and no other candidates for conspecifics (morphospecies consisting of only a single sex) are known. It is also relatively clear (in 2 of 3 cases) that the males and females of each putative species share similarities, primarily in trichome morphology, that would place them closer to each other than to any other species. Finally it is worth pointing out that this same mode of dimorphism, with females showing smoother elytra, is the same as that found in the *strigicollis* and, to a lesser extent, *pygidialis* groups. This represents at least two, and possibly three separate origins.

Chlamydopsis mallee sp. nov.
(Figs 10G-H, 11G-H, 15)

MATERIAL. HOLOTYPE ♂: 34.21S 139.31E SA, Brookfield Con. Pk., 31 Mar.-29Apr.1992, E.S.Nielsen F.I.T. #2/ F.I.T. ANIC 1233 mallee #2; in ANIC. PARATYPES (15): 8 males: same data as holotype; 1 ♂, 2 ♀♀: same but 28.v-5.viii.1992, FIT, ANIC 1260 mallee # 2; 1 ♀: same but 7.x-7.xi.1992, FIT, ANIC 1266 mallee #2; 1 ♂: same but 20.v-1.v.1993, FIT, ANIC 1297, mallee #2; 1 ♂: SA: 34.19S 139.30E, Brookfield Con. Pk., 31.iii-29.iv.1992, EN, FIT, ANIC 1232 mallee with *Triodia* #1; 1 ♂ SA: 34.22S 139.27, Brookfield Con. Pk, 30.iii-3.iv.1992, Site 3, Berlaseate ANIC 1231, *Euc.largiflorens*,clay pan, litter; in ANIC, QMB, SAM. MSCC.

DIAGNOSIS. Both males and females of this species are very similar to those of *C. variolosa* and *C. pecki*, and are only diagnosed from these two here. See above to separate these three from other *Chlamydopsis*. First, the differences between the sexes of this species are more pronounced than in the above species, and they are diagnosed separately. Males are nearly glabrous, lacking frontal and anterior marginal pronotal setae, and the originating arc of inner trichome setae is more extensive, forming a complete semicircle, rather than a short arc as in the preceding, while the humeral region as a whole is not strongly developed. The humeral trichomes of the females, on the other hand, are very strongly elevated, projecting well above the surrounding elytral surface, with the apex higher than the mesal opening. The inner trichome fringe is unique, forming a slightly rounded 'V', with only short setae projecting horizontally over the broadly exposed opening, not directed ventrally. As above, the female has conspicuous elongate setae on the frons and pronotal and elytral margins, but unlike the preceding species, has setae on the disk of the pronotum, as well as the margin.

DESCRIPTION. L: 1.93; W: 0.65; E/Pn L: 1.95; E/Pn W: 1.38; Pn W/L: 1.52; E L/W: 0.93; Pr/Py: 1.29; Sterna: 0.56, 0.12, 0.56; Tibiae: 0.72, 0.75, 0.87. Body subquadrate, rufescent brown; frons about as wide as long, sides rounded, disk reticulate, setose in female; clypeolabral suture present, labrum rounded, reticulate; antennal scapes widest near middle base, gradually narrowed to rounded apex; antennal club of male about 1.3 × length of scape, that of female about one-half as long as scape.

Prothorax about 1.3 × as wide as long; sides parallel, margined; anterior margin elevated, more so above antennal cavities than medially; anterior pronotal margin above antennae intersected by a groove extending postero-laterally from upper edge of antennal cavity to supracoxal carina in male, in female this groove is entirely obsolete; lateral and anterior pronotal margins bearing a few elongate setae; pronotal disk shallowly depressed in anterior corners, convex posteromedially, not tuberculate at middle; disk of male reticulostrigose, with strigosity longitudinally parallel anteriorly but convergent posteromedially, disk of female largely smooth, very shallowly reticulate along anterior margin.

Prosternum strongly grooved along anterior margin, this groove curving posteriorly at sides, meeting carinate circumcoxal stria; anterior margin sinuate; prosternal keel narrowed posteriorly, emarginate at apex; prosternal disk reticulate throughout, shallowly so in female.

Elytra parallel sided, convex in posterior two-thirds, depressed between humeral trichomes; humeri elevated, more strongly in

FIG. 13. Dorsal views of *Chlamydopsis* spp A, *C. pecki* (♂). B, *C. pecki* (♀). C, *C. loculosa*. D, *C. degallieri*. E, *C. papuae*. F, *C. jayawijaya*. G, *C. lucifer*. H, *C. bataviae*. I, *C. burnetta*.

female than in male; trichome of male semicircular, with mesal fringe of ventromedially directed setae, that of female forming a mesally open 'V', with short horizontal setal fringe; anterior elevation of trichome with deep superficial groove extending from anterior elytral corner to inner apex of elevation, with a few additional erect setae at apex, these arranged in a subtransverse row of bundles; anterior half of basal elytral depression with low transverse, slightly oblique elevation; elytral disk and epipleurae reticulostrigose throughout in male, smooth in female; apical half of elytra of female with numerous elongate setae, particularly along margin; elytra of male with setae only along apical margin and posterior one-fifth of elytral suture.

Mesosternum acutely projecting at middle, disk strongly strigose, depressed in anterior corners, carinate along mesometasternal suture; metasternal disk with punctures along edges, but broadly impunctate at middle; 1st visible abdominal sternite with punctures along basal margin, laterally, and, more faintly, along apical margin, but impunctate at middle; legs slender, moderately elongate, tibiae angulate at basal third, the protibia most acutely, the others less so.

Propygidium and pygidium approximately equal in length; propygidium depressed along extreme anterior margin, otherwise uniformly convex; pygidium slightly convex; propygidium and pygidium reticulately punctured and glabrous in male, smooth and bearing elongate setae in female.

REMARKS. The name of this species refers to the vegetation at the type locality, derived from the common growth form of the local *Eucalyptus*.

Chlamydopsis pecki sp. nov.
(Figs 13A, 14A, 15)

MATERIAL. HOLOTYPE ♂: Walpole NP, Peaceful Bay WA, 17-26 Jun. 1980, S.& J. Peck, SBP58/ pan traps coastal sand heath; in ANIC. PARATYPES: 1 ♀: same data as type; in ANIC.

DIAGNOSIS. Both males and females of this species are very similar to those of *C. variolosa* and *C. mallee* sp. nov., above, and are only diagnosed from these two here. See above to separate these three species from other *Chlamydopsis*. The transverse series of outer humeral setae of this species is longer than in either of the other two, extending from the apex of the trichome down approximately one-third of the epipleural surface. The setae of the anterior pronotal margin are also unusually elongate (especially in the female), while the pronotal disk is glabrous. The originating arc of the inner trichome fringe is short and only slightly curved, but about twice as long as in *C. variolosa*, approximately equivalent in length to the antennal club width in the male, and slightly longer in the female. In both sexes the setae of this inner fringe project almost directly ventrad, curving anteromesally just at their tips.

DESCRIPTION. L: 1.81; W: 0.62; E/Pn L: 1.90; E/Pn W: 1.33; Pn W/L: 1.50; E L/W: 0.95; Pr/Py: 1.07; Sterna: 0.50, 0.12, 0.50; Tibiae: 0.69, 0.75, 0.84. Points of difference from *C. mallee* sp. nov., described in full above, are noted in the diagnosis.

REMARKS. This species is named in honor of Stewart and Jarmila Peck, collectors of the types, whose worldwide work has furnished valuable material for countless beetle studies.

Chlamydopsis loculosa Lea, 1925
(Figs 13C, 14C, 15)

Chlamydopsis loculosa Lea, 1925: 254; Lectotype ♀, hereby designated: Lea, Type, *loculosa*, Beverley / 15775 *Chlamydopsis loculosa* Lea, W. Australia Type; SAM, examined, 2002; paralectotype ♀: same data as type (mounted on the same card); these two type specimens are mounted side by side on a single card. 'TY' had previously been written on the card behind the left-most specimen; this is the specimen designated here as the Lectotype. An additional paralectotype has been designated in the AMS from the same locality. The type series originally included specimens from Swan River, WA; their current repository is unknown.

RECORDS. NHM: WA: Beverley; WAM: all WA: Beverley; Culham; Bejoording; New Norcia, Spencer's Brook, Midland, Murchison River. SAM: SA: Gammon Ra. NP, Weetootla Gorge, under stones, 16.ix.1990; ANIC: WA: Midland, 7.vi.48; NSW: 15km N of Coombah, 31.x.1975, on worker in *Rhytidoponera maniae* nest (#1438), P.S.Ward (1); NSW: Kinchega NP, 32.30S, 142.20E, iii.1986, red sand dune. McMillan (1950): all WA: Bunbury; Perth (King's Park); Guildford; West Midland; Spencer's Brook; Northam; Bolgart; Albany.

DIAGNOSIS. L: 2.52; W: 0.93; E/Pn L: 1.70; E/Pn W: 1.42; Pn W/L: 1.27; E L/W: 0.94; Pr/Py: 1.17; Sterna: 0.69, 0.31, 0.72; Tibiae: 1.25, 1.37, 1.71. *C. loculosa* can be easily distinguished from all other *Chlamydopsis* by its small nonsetose trichomes. The humeri are not elevated; a deep humeral groove extends from the anterolateral elytral corners into a simple deep pit, the diameter of which is only about 2× the width of the humeral groove. The legs of *C. loculosa* are also unusually elongate, with nearly

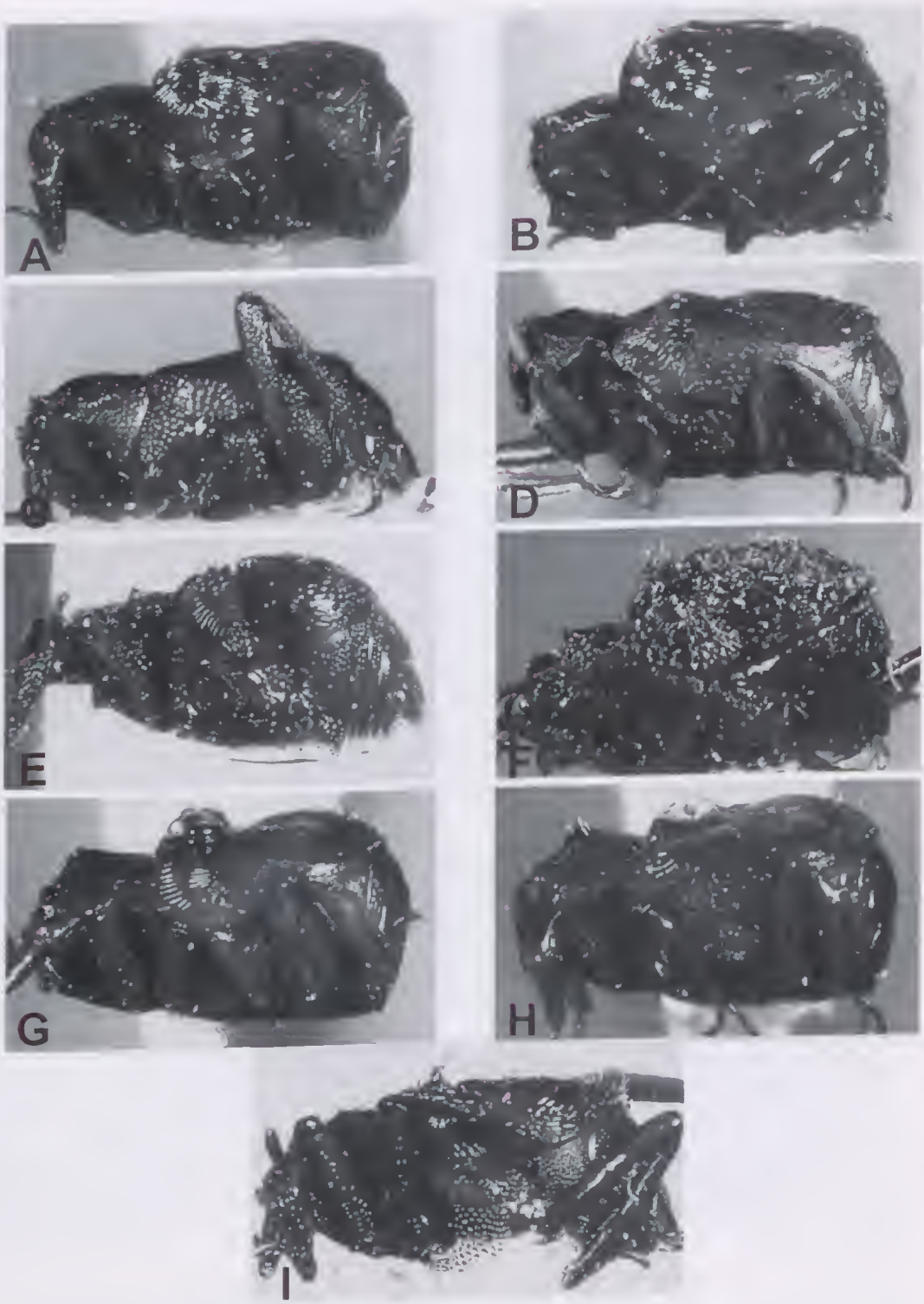

FIG. 14. Lateral views of *Chlamydopsis* spp. A, *C. pecki* (♂). B, *C. pecki* (♀). C, *C. loculosa*. D, *C. degallieri*. E, *C. papuae*. F, *C. jayawijaya*. G, *C. lucifer*. H, *C. bataviae*. I, *C. burnetta*.

one-fourth of the meso- and metafemora extending above the dorsal surface of the elytra when the legs are retracted; the outer marginal angulations of the meso- and metatibiae are also poorly developed.

REMARKS. McMillan (1950) published some interesting observations on the biology of *C. loculosa* (erroneously as *C. duboulayi* Westwood; McMillan, 1954). The very elongate legs are apparently not locomotory specialisations, as is commonly assumed, but facilitate phoresy, serving to grasp the thorax of their ponerine hosts (see Table 1).

Chlamydopsis degallieri sp. nov.
(Figs 13D, 14D, 15)

MATERIAL. HOLOTYPE ♂: 20km E Norseman WA, 12-13 Jan. 1986, Reid, Gullan&Lewis, light trap in tall mallee/Melaleuca scrub; in ANIC. PARATYPES (6): 5 males: same data as holotype; 1 ♂.: SA: ~15km SSE of Streaky Bay, 20-21.xii.1985, Reid, Gullan&Lewis, ex. light trap in mallee scrub; in ANIC, SAM, MSCC.

DIAGNOSIS. *Chlamydopsis degallieri* sp. nov. is a distinctive member of this group. While it bears a distinct anterolateral pronotal groove, this groove lies outside prominently elevated lateral pronotal margins, which are continuous with the more weakly elevated anterior pronotal margin. This is a unique configuration in *Chlamydopsis*. In general body form, and in its essentially unelevated humeral trichomes, it resembles *C. loculosa*, and the two may be related. However the trichome of *C. degallieri* bears conspicuous mesal setae, and its legs are not unusually elongate.

DESCRIPTION. L: 2.43; W: 0.78; E/Pn L: 2.12; E/Pn W: 1.37; Pn W/L: 1.52; E L/W: 1.02; Pr/Py: 1.13; Sterna: 0.62, 0.16, 0.81; Tibiae: 0.81, 0.93, 1.03. Body elongate, light rufescent brown, most surfaces nearly uniformly reticulately punctate, with conspicuous granulate microsculpture within punctures. Frons about as wide as long, sides rounded; clypeolabral suture straight to slightly outwardly arcuate; labrum short, rounded; antennal scape widest near middle, outer margin subacutely angulate, narrowed to rounded apex; antennal club of male about 1.2× as long as scape.

Prothorax about 1.5× as wide as long; sides margined, elevated, continuous with anterolateral portion of anterior margin, slightly narrowed to front; anterior pronotal margin somewhat interrupted between medial and anterolateral portions; pronotal disk depressed along lateral and anterior margins, but convex medially.

Anterior margin of prosternum deeply grooved, sinuate, acutely projecting on either side; prosternal disk slightly transversely depressed behind anterior margin; prosternal keel narrowed posteriorly, elevated between coxae, emarginate at apex; prosternal disk uniformly punctate, punctures with granulate microsculpture within.

Elytra 1.5× as wide as pronotum, parallel sided, narrowed in basal one-fifth and apical one-fourth; humeral trichomes weakly elevated, trichome opening small, mesal, with fringe of setae, some of which are erect and extend dorsally above subacute peak of trichome; elevation of trichome slightly furrowed laterally; humeral groove present, slightly arcuate, extending from anterolateral elytral corner to opening of trichome, meeting an oblique, blunt ridge extending from anterior margin next to scutellum; blunt, transverse tubercles present on each side behind scutellum; scutellum small.

Mesosternum about 2× as wide as long, anterior margin projecting at middle; disk punctate as in prosternum; mesometasternal suture visible not strongly impressed; metasternal disk elevated, strongly convex in posterior three-fourths, moderately punctate in anterior one-fourth and at sides, punctures smaller and sparser along midline and posterior margin; 1st visible abdominal sternite uniformly moderately punctate; legs not elongate, all tibiae bluntly angulate about one-third from base.

Propygidium and pygidium about equally long medially; propygidium shallowly depressed along anterior margin, otherwise moderately convex; pygidium convex medially, faintly depressed along apical edges; propygidium uniformly reticulate/granulate, the pygidium reticulate only in basal half.

REMARKS. This species is named in honor of my valued chlamydopsine collaborator, Nicolas Dégallier.

Chlamydopsis papuae Lewis, 1913
(Figs 13E, 14E, 15)

Chlamydopsis papuae Lewis, 1913: 86; MATERIAL. HOLOTYPE ♂: Laloki, Papua, F. Muir, 1910; NHM, examined, 2000.

DIAGNOSIS. *Chlamydopsis papuae* and the following species are closely related, and represent the only *Chlamydopsis* known from New Guinea.

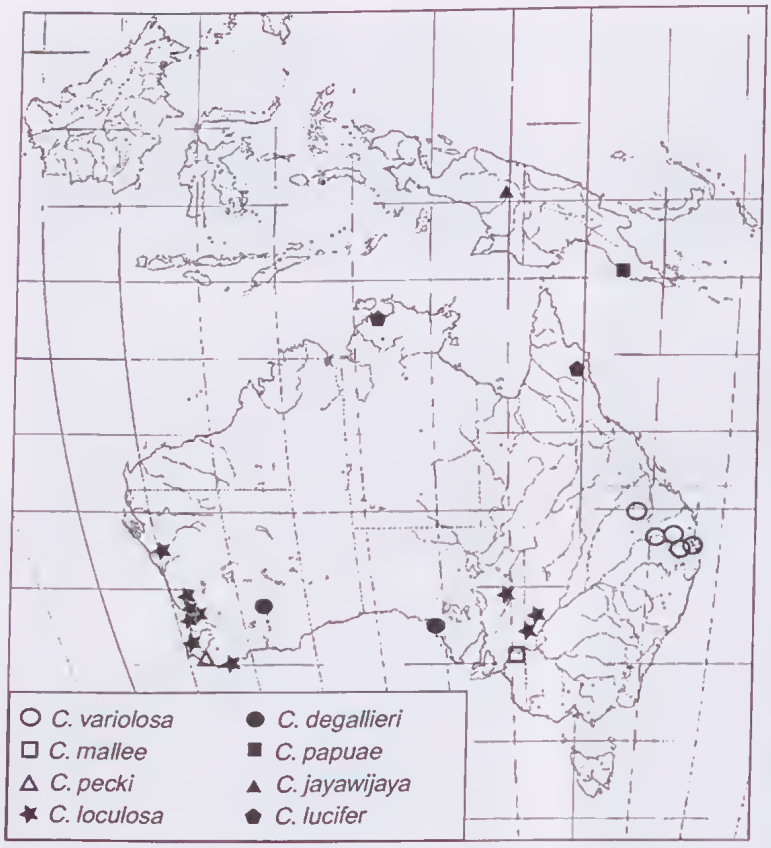

FIG. 15. Collecting records for species of *Chlamydopsis ectatommae* group.

Both have the anterolateral pronotal groove distinct and interrupting the lateral portion of the anterior pronotal margin. Both have a small but acute median pronotal tubercle. Although both species have the dorsal surfaces entirely reticulostrigose, the seuplturing of *C. papuae* is generally less dense. The elytra of *C. papuae* exhibit some flat surface among the posterior strigosity, whereas the dense sculpture of the elytra of *C. jayawijaya* is uninterrupted. The pronotal punctation differs, with that of *C. papuae* more generally consisting of nearly polygonal punctures and that of *C. jayawijaya* entirely strigose. The epipleural sculpturing is also somewhat different with the strigosity of *C. papuae* arched, but largely continuous under the trichome, whereas that of *C. jayawijaya* converges to the trichome, with nearly all strigae discontinuous beneath it.

REMARKS. This species is known only from the type.

Chlamydopsis jayawijaya
sp. nov.
(Figs 13F, 14F, 15)

MATERIAL. HOLOTYPE ♂: Diuremna (nr. Nalca) [~4°22'S, 139°51'E], 1900-2100m, 9-11.XI.1992/ IRIAN JAYA, Jayawijaya Prov., leg. A. Riedel; in BMNH.

DIAGNOSIS. See above under *C. papuae*.

DESCRIPTION. L: 2.87; W: 1.00; E/Pn L: 1.88; E/Pn W: 1.50; Pn W/L: 1.63; E L/W: 0.77; Pr/Py: 1.00; Sterna: 0.87, 0.25, 0.97; Tibiae: 1.21, 1.34, 1.56. Body large, elytra broad, quadrate; pronotum narrower; nearly black, very slightly rufescent, strongly reticulostrigose on all dorsal surfaces. Frons and antennal scapes strongly reticulated, sides of frons slightly rounded; labrum rounded, reticulate; antennal scape widest one-third from base, slightly tapered to rounded apex; antennal club of male about 1.25 × length of scape.

Prothorax about 2 × as wide as long, sides unmargined, inwardly arcuate, slightly narrowed toward front but abruptly expanded around antennal cavities; anterior pronotal margin strongly elevated but interrupted in several places; an oblique groove extending posterolaterally from each antennal cavity to the supracoxal carina; transverse anteromedial portion of pronotal margin separated from nearly semicircular portion delimiting each antennal cavity; transverse medial portion also notched at middle; pronotal disk with acute median tubercle, and less conspicuous tubercles on each side near base; disk depressed behind anterior margin, elevated at middle, with small but deep medial depression in front of scutellum.

Prosternal anterior marginal groove continuous with circumcoxal stria; anterior prosternal margin sinuate, projecting on each side; prosternal keel narrowed between coxae, widening out slightly behind, acutely emarginate at apex, disk densely reticulopunctate.

Elytra parallel-sided, narrowed basally and apically, transversely elevated just behind middle, depressed basally between trichomes; anterior and posterior elevations of trichomes enclosing circular dorsal opening, nearly, but not quite meeting mesally, all inner and upper margins of elevations apparently lined with short setae; anterior elevation of trichome higher than posterior, nearly acute at apex, with a few dorsally and posteriorly directed setae near apex, with conspicuous, curved anterior groove from anterior elytral corner to inner apex; anterior half of basal depression differentiated from posterior, slightly elevated, punctate, and setose, elsewhere reticulostrigose and more or less glabrous; elytral epipleurae reticulostrigose, strigosity convergent to trichome; marginal stria of epipleuron delimiting a conpicuous smooth marginal bead.

Mesosternum projecting anteriorly, about 4× as wide as median length, densely reticulopunctate; mesometasternal suture deeply and crenulately impressed; longitudinal metasternal suture shallowly impressed but visible, disk impunctate except near metepisternum; first visible abdominal sternite with punctures along anterior margin and at sides but impunctate at middle; legs slender, elongate; tarsal groove of tibiae straight, parallel to tibial axis; outer margin of tibiae angulate at apex of tarsal groove (near basal one-third).

Propygidium about two-thirds length of pygidium at middle, depressed along anterior margin and at sides, but convex medially; pygidium very slightly convex; propygidium and pygidium uniformly reticulopunctate, with sparse but conspicuous setae.

REMARKS. This species is named for the New Guinean province encompassing the type locality.

Chlamydopsis lucifer sp. nov.
(Figs 13G, 14G, 15)

MATERIAL. HOLOTYPE (QMT108586) ♂: N.T., 6km E of Humpty Doo [~12.6°S,131.25°E], 6-19.x.1990, R.I. Storey at UV light. PARATYPE: 1 ♀: NEQ: Hann R. N of Laura [~15.6°S,144.4°E], 20.iii-24.iv.1994, PZ, FIT.

DIAGNOSIS. This species and the following are similar and diagnosed together here. The two may be separated from other species of the *ectatommae* group by the combination of a very prominent, acute median pronotal tubercle, and a well delimited, outwardly arcuate trichome which is somewhat removed from the lateral elytral margin, with a distinct, horizontal 'shoulder' laterad. This mesal displacement also results in the anterior superficial humeral groove extending more obliquely inward from the humeral corner, curving upward to the inner corner of the trichome's arcuate setal fringe. The trichomes of *C. lucifer* define a much deeper arc than do those of *C. bataviae* (compare Figs 13G and 13H). In both, the origins of the inner setal fringe are horizontally toward the centre of their arc. In *C. lucifer* the apices of these setae are curved ventrad, whereas in *C. bataviae* they curve dorsad.

DESCRIPTION. L: 1.93; W: 0.75; E/Pn L: 1.58; E/Pn W: 1.29; Pn W/L: 1.42; E L/W: 0.86; Pr/Py: 1.00; Sterna: 0.53, 0.12, 0.59; Tibiae: 0.62, 0.65, 0.75. Body rufescent, elytra light orange, pronotum darker, body reticulately punctate throughout (though with some variation in density); most surfaces with sparse short setae. Frons slightly wider than long, sides rounded, disk reticulopunctate, glabrous; labrum rounded; antennal scapes arcuate, widest at middle, narrowed slightly to rounded apex, surface punctate, microsculptured between punctures.

Pronotum one-fifth wider than long, sides margined, narrowed to front; anterior margin slightly elevated above antennal fossae, medial portion above head not elevated; anterolaterally with groove extending from edge of antennal fossa posterolaterally to supracoxal carina; pronotum raised at middle, with a single acute dorsal tubercle near the middle; entire pronotal disk, including tubercle, strongly reticulostrigose, lateral strigosity tends to diverge around tubercle and converge both posteriorly and anteriorly.

Prosternum with anterior margin sinuate, grooved, this groove continuous with circumcoxal stria; prosternal keel narrowed posteriorly, emarginate at apex, prosternal disk mostly densely punctate, with interstices conspicuously microsculptured.

Elytra about one-third wider than pronotum, markedly lighter in color, parallel-sided, narrowed in basal and apical fifths; humeral trichomes, more or less shelf-like laterally, but with discrete, elevated bead at base of semicircular setal fringe, with dense, inwardly directed fringe of convergent setae, curving ventrad at their apices, open beneath this fringe; anterior surface of trichome with oblique groove extending from anterolateral corner of elytron to leading edge of setal fringe; most of elytral disk reticulostrigose, except upper one-third of lateral surface of trichome smooth; sparse but

conspicuous setae along apical margin of elytron and along apical half of elytral suture; few short setae on anterior elevation of trichome and in basal elytral depression.

Mesosternum projecting, densely punctate; mesometasternal suture impressed; metasternal disk with row of punctures along all edges but only sparsely punctate in middle of disk; 1st visible abdominal sternite sparsely punctate throughout, with punctures slightly denser along anterior margin; legs not elongate, moderately slender, the posterior (lower) surface of profemur densely punctate, the protibia and the meso- and metafemora and tibiae not conspicuously punctate but with distinct microsculpture and sparse setae.

Propygidium slightly longer than pygidium along midline; propygidium depressed just along anterior margin, otherwise strongly convex, densely reticulopunctate throughout, interstices microsculptured; pygidium flat to slightly convex, punctate in basal half, microsculptured throughout.

REMARKS. The single female from Queensland differs slightly as follows: opening of trichome slightly larger, particularly extended slightly forward along anterior edge; also base of trichome's upturned edge slightly constricted, such that there is a distinct 'shelf' surrounding it; elytra less strongly strigose, especially posterolaterally. Additional material is needed to determine whether these differences are individual, sexual, or geographic. The name of this species refers primarily to the fact that the type was collected at light, which is very unusual in histerids. Secondarily, the setae of the trichome converge and recurve in a manner suggesting horns.

Chlamydopsis bataviae sp. nov.
(Figs 13H, 14H, 18)

MATERIAL. HOLOTYPE (QMT108587) ♂: 12.43S 142.42E Qld, 7km S. of Batavia Downs, 19 Jun - 22 Jul 1992, Flight Intercept Trap, P.Zborowski & J.Cardale. PARATYPE: 1 ♂: same locality as type, 22.vi-23.vii.1992, PZ&EN, FIT; in DPIM.

DIAGNOSIS. See above where this species and the previous are diagnosed together.

DESCRIPTION. L: 1.96; W: 0.78; E/Pn L: 1.52; E/Pn W: 1.27; Pn W/L: 1.48; E L/W: 0.81; Pr/Py: 1.13; Sterna: 0.56, 0.12, 0.59; Tibiae: 0.78, 0.72, 0.84. This species is very similar to, and closely related to *C. lucifer* above, and a complete description is not given here. The form of the humeral trichome is the primary distinguishing character. In *C. bataviae* the humerus is not as strongly elevated, and the mesal fringe is not borne on a distinctly elevated ring as it is in the preceding species. The mesal edge forms a blunt, obtuse,'V', with the setal fringe curving upward and slightly outward, converging above opening, with just a few short inwardly and ventrally directed setae beneath the upper fringe. Lateral to the trichome there is a broad, nearly flat humeral 'shelf'. Elytral surface thoroughly reticulostrigose, but shallowly so, particularly posterolaterally.

REMARKS. This species takes its name from the type locality.

Chlamydopsis burnetta sp. nov.
(Figs 13I, 14I, 18, 28C, 29E)

MATERIAL. HOLOTYPE (QMT108588) ♀, dissected by the author: SEQ: 25°40'S 151°26'E, Nipping Gully, Site 4, 9Oct-18Dec1998, Monteith&Gough,200m, Open forest Intercept. 7502, in QMB. PARATYPE: 1 ♀: SEQ: 25°40'S 151°26'E, Nipping Gully, Site 4, 18.xii.98-26.i.1999, GM & Gough, 280m, O/For., FIT, 7570, in QMB.

DIAGNOSIS. This and the four species that follow form a very distinctive, and clearly monophyletic, subgroup within the *ectatommae* group. The most conspicuous characteristic of the group is the dense bundle of setae on the transverse carina of the mediobasal elytral depression. In *C. pilosipes* sp. nov. this bundle consists of only a few thin setae, but in all the others it forms a large patch of at least eight or more setae. The trichome structure of the group is somewhat varied, but is in all cases distinct from any others of the *ectatommae* group, never forming a simple mesal arc of setae. These five also share: relatively elongate narrow body; elongate legs; numerous pronotal, elytral, and pygidial discal setae (many of them small setal bundles); convex pronotal disk with weakly produced, short transverse median tubercle (except in *C. contorta*). Most are known from both sexes, and show no obvious dimorphisms. *Chlamydopsis burnetta*, *C. zborowskii* and *C. pluriseta* are particularly similar, with a humeral trichome that has a somewhat obliquely transverse, quadrate dorsal opening, filled with a very short but dense setal mat. In neither *C. burnetta* nor *C. pluriseta* does the setose region of the trichome reach the lateral edge of the elytra. A short smooth transverse furrow, approximately half the width of the setose area itself, incises the lateral aspect of the humeri. In *C. zborowskii* the setose patch is larger, its lateral

corner extending most of the way to the lateral humeral edge. The principal difference between *C. burnetta* and *C. pluriseta* is size, (2.8 v. 2.4mm PE length, respectively) along with the probably correlated longer legs of *C. burnetta*. Also in *C. burnetta*, the metasternal disk is densely and contiguously punctate throughout, while in *C. pluriseta* all specimens show some impunctate space, and are often entirely smooth at sides.

DESCRIPTION. L: 2.74; W: 1.03; E/Pn L: 1.67; E/Pn W:1.43; Pn W/L: 1.39; E L/W: 0.83; Pr/Py: 1.11; Sterna: 0.75, 0.22, 0.90; Tibiae: 1.37, 1.50, 1.74. Body elongate, dark rufescent, mostly reticulate above, and with sparse elongate setae (a few bundles of setae) nearly throughout. Frons about as wide as long, sides rounded, anterior margin very slightly outwardly arcuate; disk deeply reticulate, with a few conspicuous setae; labrum rounded, reticulate; antennal scapes widest at middle, slightly narrowed to rounded apex, reticulate, setose; antennal club of female approximately as long as scape.

Prothorax about one-third wider than long, widest near base, sides margined, sinuate to front; anterior margin elevated, the anterolateral portions more so than medial portion; antero-lateral portion of margin delimited laterally by a sinuate groove extending from above antennal fossa posterolaterally where it joins supraocxal groove; pronotal margins with approximately evenly spaced, prominent bundles of setae; pronotal disk depressed behind anterior margin and just in front of scutellum, otherwise strongly convex, acutely produced at middle, bearing scattered setal bundles.

Prosternum with deep anterior marginal groove, margin sinuate and acutely projecting on each side; prosternal keel narrowed posteriorly, emarginate at apex, convex; prosternal disk reticulate and with scattered setae.

Elytra about 1.5× as wide as pronotum, parallel sided, narrowed in basal one-sixth and apical one-fourth; elytra convex in most of apical two-thirds (depressed in posterolateral corners) transversely depressed in basal one-third, this basal depression with low transverse carina bearing large bundle of setae close to elytral suture; humeral trichomes prominent, anterior aspect nearly vertical (in lateral view); anterior and posterior elevations of trichome separated by shallow lateral furrow which is continuous with mesal opening of trichome; opening of trichome nearly rectangular, widest transversely but offset about 30° from horizontal (towards anterior corners); mesal fringe of trichome dense and erect but very short; anterior elevation with nearly straight superficial groove, extending from anterior corners of elytra to anterior corners of rectangular trichome opening, and with several prominent setal bundles near apex; elytral disk reticulostrigose and with scattered setae except within basal depression.

Mesosternum 2.2× as wide as long; anterior margin acutely projecting at middle; disk deeply reticulate; mesometasternal suture deeply impressed; metasternal disk and 1st abdominal sternite uniformly densely punctate (though slightly less densely than mesosternum). Legs elongate, slender, about one-fifth of metafemoral length projecting above elytra when held vertically; femora slightly clavate; outer margins of tibiae angulate at about their midpoint.

Propygidium about as long as pygidium along midline, slightly depressed along basal margin, but otherwise strongly convex; pygidium convex; both propygidium and pygidium strongly reticulate, with sparse elongate setae.

REMARKS. This species takes it name from the watershed (Burnett River) encompassing the type locality.

Chlamydopsis zborowskii sp. nov.
(Figs 16A, 17A, 18)

MATERIAL. HOLOTYPE (QMT108589) ♂: 12.40S 142.39E Qld, 3km W Batavia Downs, 24 Oct-23 Nov 1992, Flight Intercept Trap, P.Zborowski & A.Calder. PARATYPES (5): 1 ♂, 1 ♀: same locality as holotype but 16.ix-24.x.1992; 1 ♂, 1 ♀: same but 23.viii-16.ix.1992; 1 ♀: Qld: 12.40S, 143.00E, 13km E by S Weipa, 15.viii-12.ix.1993, FIT,PZ&SS, in QMB, DPIM, MSCC.

DESCRIPTION. L: 2.40; W: 0.90; E/Pn L: 1.66; E/Pn W: 1.41; Pn W/L: 1.41; E L/W: 0.83; Pr/Py: 1.06; Sterna: 0.72, 0.19, 0.81; Tibiae: 1.09, 1.15, 1.34. This species and the following are very similar to the preceding species and are only described to the extent that they differ from it. Setal patch of humeral trichome larger, extending laterally to the side of the humeral dorsum; inner apex of posterior elevation of trichome more protuberant dorsally and anteriorly, nearly closing the mesal opening above; strigosity of pronotum and elytra finer (narrower and more elongate), and on elytra less deeply impressed, some individuals (especially the females) almost impunctate behind trichomes; legs less elongate, metafemur barely projecting above elytra when held vertically; punctures of metasternum confined to middle portion of disk, sides

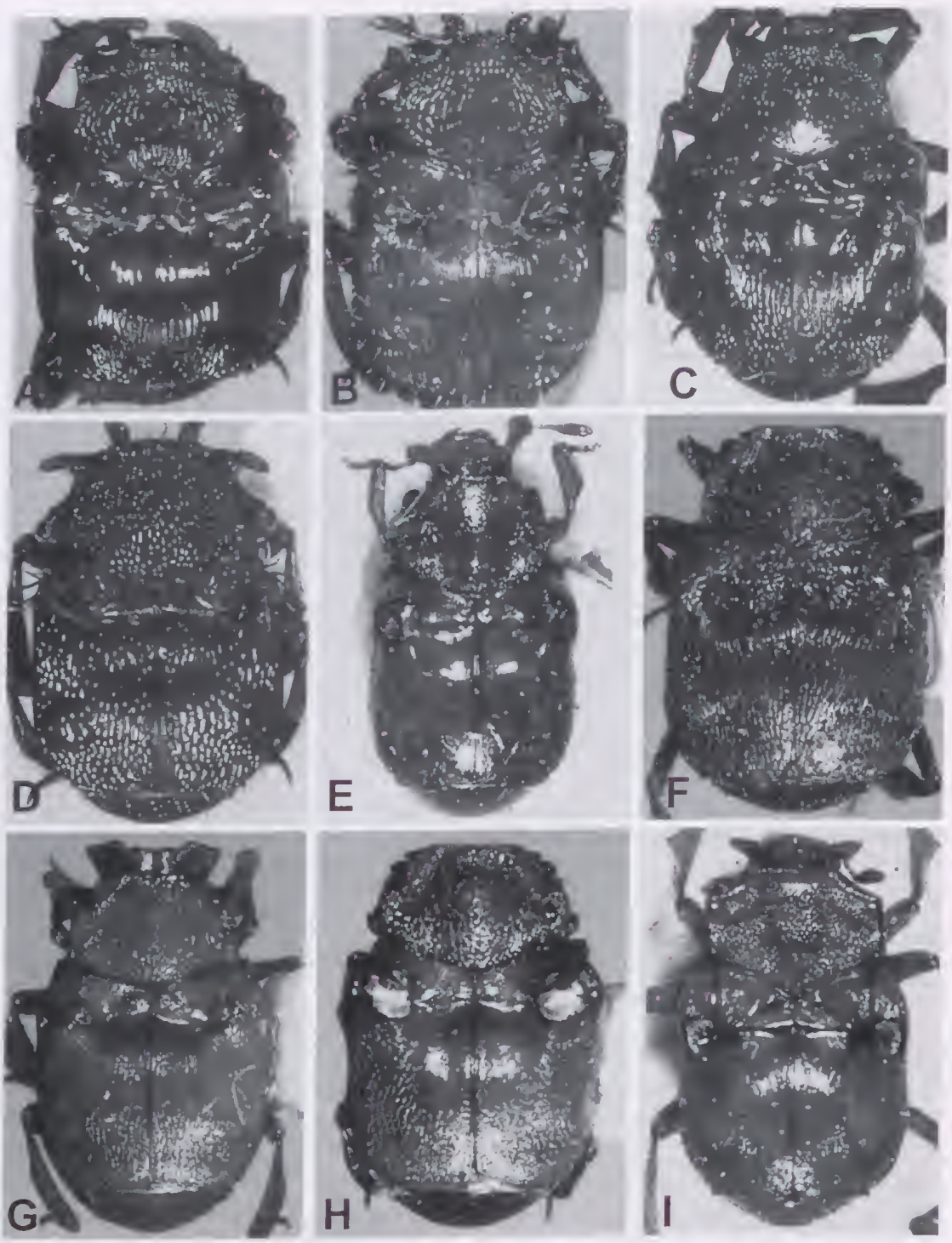

FIG. 16. Dorsal views of *Chlamydopsis* spp. A, *C. zborowskii*. B, *C. pluriseta*. C, *C. contorta*. D, *C. pilosipes*. E, *C. bifovaecollis*. F, *C. nielseni*. G, *C. australis*. H, *C. lepida*. I, *C. epipleuralis*.

impunctate; lateral portion of 1st visible abdominal sternite also less punctate, with no punctures within postmetacoxal depression.

REMARKS. It is unusual to have two such similar and obviously related species as this and the following collected at the same locality, over several of the same trapping periods. Yet both forms are known from both sexes, and the differences between them are absolutely consistent among all specimens. It would be very interesting to know if they share hosts. This species is named in honor of Paul Zborowski, collector of this type, as well as many other interesting chlamydopsines.

Chlamydopsis pluriseta sp. nov.
(Figs 16B, 17B, 18)

MATERIAL. HOLOTYPE (QMT108590) ♂: 12.39S 142.42E Qld, 4km NE Batavia Downs, 24 Oct-23 Nov, 1992, P. Zborowski &A.Calder. PARATYPES (11): 1 ♂, 1 ♀: same data as holotype; 1 ♂, 1 ♀: same but 23.xi-11.xii. 1992; 4 ♂♂, 3 ♀♀: same but 16.ix-24.x.1992, in QMB, DPIM, ANIC, MSCC.

DESCRIPTION. L: 2.31; W: 0.87; E/Pn L: 1.64; E/Pn W: 1.32; Pn W/L: 1.46; E L/W: 0.85; Pr/Py: 1.00; Sterna: 0.69, 0.22, 0.81; Tibiae: 1.09, 1.12, 1.34. See *C. burnetta* above to separate this species and the preceding two from all other *Chlamydopsis*. This species differs from *C. burnetta* in only a few characters: size smaller, (2.4mm v. 2.8mm PE length); legs less elongate, tips of metafemora not or barely projecting above elytral dorsum when held vertically; inner edge of posterior elevation of trichome projecting further forward, nearly closing trichome opening mesally; metasternal disk with fewer punctures at sides, often entirely impunctate.

REMARKS. The name of this species refers to the conspicuous setae on most body surfaces (which it shares with most of this subgroup).

Chlamydopsis contorta sp. nov.
(Figs 16C, 17C, 18)

MATERIAL. HOLOTYPE (QMT108591) ♂: C. Qld: 22°02'S 148°03'E, Moranbah, 5km S. 240m, 20 Dec 97-26 Apr 1998, G.Monteith, Flt.Intercept,Bendee Scrub. 5799. PARATYPES: 3 males: same locality as holotype but 25.vi-20.xii.1997, GM&E. Kruck, FIT, Bendee Scrub, 5642, in QMB, MSCC.

DESCRIPTION (compared with *C. burnetta*, described in full above). L: 2.62; W: 0.97; E/Pn L: 1.71; E/Pn W: 1.39; Pn W/L: 1.48; E L/W: 0.83; Pr/Py: 1.17; Sterna: 0.75, 0.22, 0.87; Tibiae: 1.12, 1.21, 1.46. Body broader, reticulation generally less deeply impressed; body setae fewer and single (no bundles of setae, with one exception noted below); lateral margins of pronotum mostly straight, convergent to near apex, then expanded around antennal fossae, without lateral marginal setae; oblique groove between antennal fossa and circumcoxal stria absent (though a faint vestigial furrow can be seen); pronotal disk not as strongly convex, with slight indication of transverse medial carina in two of four specimens, with a few single setae near middle, but lacking presentellar setae (seen in both *C. burnetta* and *C. pilosipes*); humeral trichomes not at all rectangular, almost 'V'-shaped in dorsal view (the bottom of the 'V' directed anteriorly) , the outer arm of the 'V' continuous with a rather deep lateral furrow; anterior elevation of trichome divided by anterior superficial groove, the outer half more strongly produced, more or less acute in lateral view; bundle of setae along mediobasal transverse carina more extensive, occupying the entire apex of the carina; metasternum and 1st visible abdominal sternite almost entirely impunctate, each with only a few shallow punctures along anterior margin; legs not as elongate, angle of outer margin of tibiae nearer basal third than midpoint.

REMARKS. The name of this species refers to the sinuate contours of the humeral trichome.

Chlamydopsis pilosipes sp. nov.
(Figs 16D, 17D, 18)

MATERIAL. HOLOTYPE (QMT108592) ♀: SEQ: 25°13'S 149°01'E, Expedition Ra. Nat. Pk, 5729, 'Amphitheatre' yards. 440m, 19 Dec 97-4 Mar 1998. Cook & Monteith. open for.intercept.

DIAGNOSIS. *Chlamydopsis pilosipes* is the most distinctive species of this subgroup. The opening of the humeral trichome is entirely different from the others, consisting mainly of a small, but quite deep dorsal pit, continuous anteriorly with the superficial humeral groove, and almost concealed above by an acute, leaflike, posteriorly directed projection from the inner edge of the anterior humeral elevation. Additionally the setal bundles of the mediobasal elytral carinae consist of only a few setae, and the legs are covered with fairly dense decumbent setae, whereas those of the other species have sparser, mostly erect setae.

DESCRIPTION. L: 2.43; W: 0.93; E/Pn L: 1.60; E/Pn W: 1.53; Pn W/L: 1.27; E L/W: 0.83; Pr/Py:

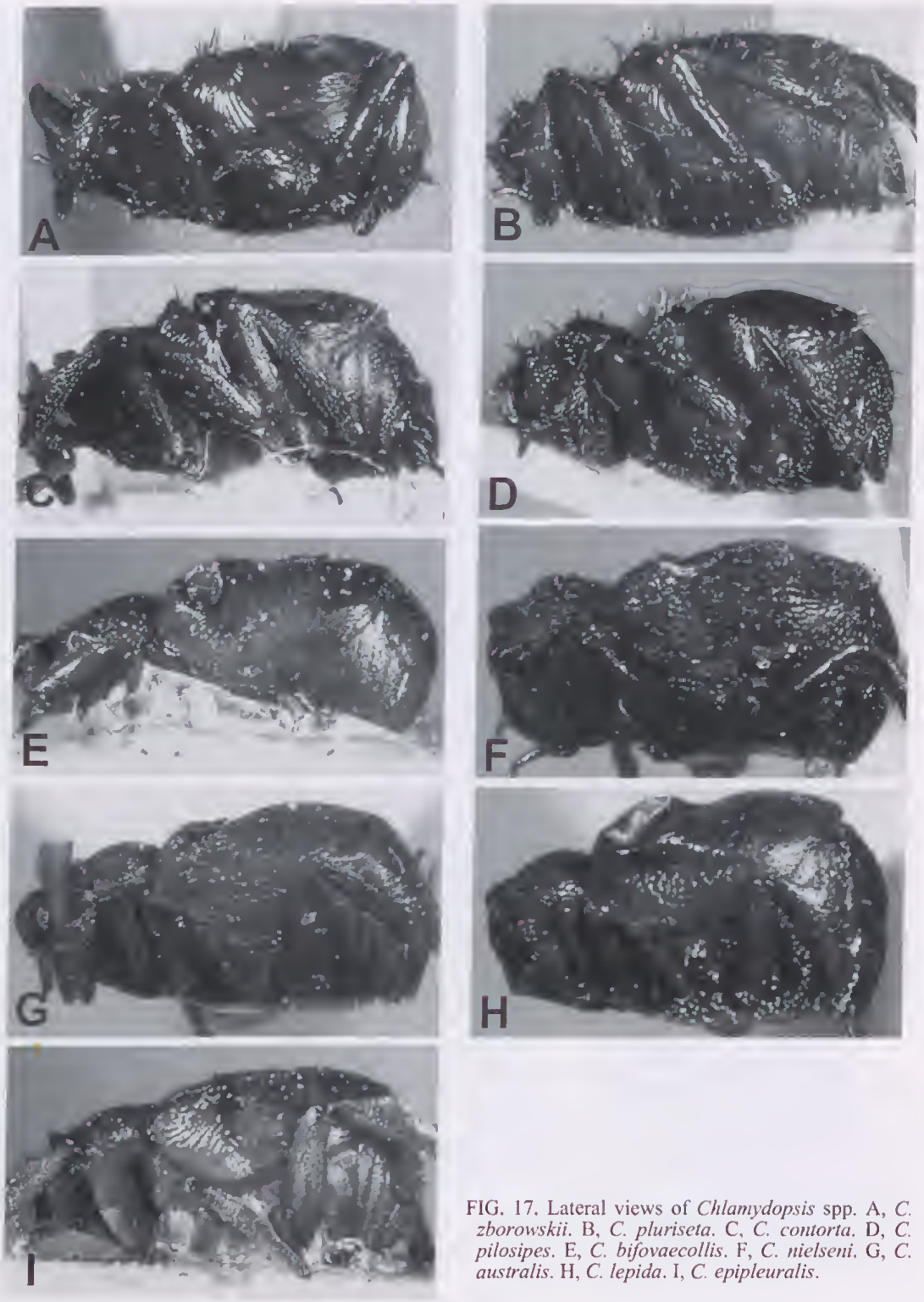

FIG. 17. Lateral views of *Chlamydopsis* spp. A, *C. zborowskii*. B, *C. pluriseta*. C, *C. contorta*. D, *C. pilosipes*. E, *C. bifovaecollis*. F, *C. nielseni*. G, *C. australis*. H, *C. lepida*. I, *C. epipleuralis*.

1.38; Sterna: 0.62, 0.22, 0.69; Tibiae: 1.06, 1.03, 1.15. Body elongate, subquadrate, rufescent, reticulostrigose throughout, most surfaces (except for posterior two-thirds of elytra) with long, prominent setae or bundles of setae; frons about as wide as long, sides rounded, anterior margin straight, with about 6 prominent setae; labrum rounded; mandibles bearing a couple setae on outer surfaces; antennal scape widest near middle, faintly tapered to rounded apex, with a few setae.

Prothorax about one-third wider than median length, sides unmargined, sinuate, widest near base, narrowing anteriorly, then abruptly widened around antennal fossae; anterior margins of pronotum elevated, anterolateral portions strongly raised, rounded, interrupted by groove extending from edge of antennal fossa posterolaterally to supracoxal hypomeral groove; medial portion of anterior pronotal margin not as strongly elevated as anterolateral portions but more or less continuous with them; anterior and lateral pronotal margins with prominent bundles of setae; pronotal disk depressed behind anterior margin, otherwise strongly convex, subacutely produced at middle, prescutellar region slightly depressed; pronotal disk with numerous conspicuous setae, their arrangement not quite symmetrical; one especially prominent pair of setae just in front of scutellum.

Prosternum with anterior margin strongly grooved, sinuate, acutely projecting on either side; prosternal keel narrowed posteriorly, not elevated, reticulate and sparsely setose.

Elytra about 1.5× width of pronotum, sides more or less parallel, narrowed in apical one-third and basal one-fourth; transversely depressed in mediobasal one-third, with low, setose, transverse carinae within depression; humeral trichomes prominent, with conspicuous bundles of setae on anterior and lateral surfaces; anterior elevation of trichome divided by deep superficial groove, prominent and acutely produced on either side of this groove, the inner portion tapered, leaflike, extending posteriorly to cover much of dorsal opening of trichome, the small, depressed opening apparently lacking a marginal fringe of setae; posterior elevation of trichome as high as anterior ones, but merely convex above; elytral disk entirely reticulostrigose, but this texture less strongly developed at middle; apical elytral margin with fringe of conspicuous setae.

Mesosternum about 2.2× as wide as median length, acutely projecting at middle, densely reticulopunctate and sparsely setose; mesometasternal suture finely impressed; metasternum densely punctate anteriorly and laterally but less so posteromedially, with punctures rounder, shallower and separated by about one-half their widths; 1st visible abdominal sternite almost uniformly punctate, the punctures separated by slightly less than their widths, those of the anterior and posterior margins more closely spaced; Legs elongate slender, the meso- and metafemora slightly elavate, outer margins of all tibiae angulate near middle; outer surfaces of meso- and metatibiae smooth near bases but increasingly strigose towards apices; all legs densely setose, most or all setae single (not in bundles).

Propygidium about one-fourth longer than pygidium, slightly depressed just along basal margin, but otherwise strongly convex; pygidium convex; both propygidium and pygidium strongly reticulate, with sparse elongate setae.

REMARKS. The name of this species refers to its conspicuously setose legs.

Chlamydopsis bifovaecollis (Oke, 1923)
(Figs 16E, 17E, 18, 29A)

Orectoscelis bifovaecollis Oke, 1923: 159; New Combination; MATERIAL. HOLOTYPE prob. ♀: Natya, Vic. 29.9.1922, C. Oke/ *Orectoscelis bifovaecollis*, Oke. Type./ Presented by C.G. Oke/ 904 Type/ MATERIAL. HOLOTYPE. T. 904 *Orectoscelis bifovaecollis* Oke, 1923; MVM, examined, 2000.

DIAGNOSIS. This species and the following three represent a distinctive clade, which may or may not belong in the *ectatommae* group. They are highly distinctive, having an anterolateral pronotal groove extending from the posterior edge of the antennal cavity posteriorly to conspicuous pits on the pronotal dorsum (Fig. 29A). Placement of these species in the present group is based primarily on the (questionable) assumption of homology between these grooves and the oblique grooves of the other members of the *ectatommae* group. The shape of the humeral trichome is also similar to that of some other *ectatommae* group species (particularly *C. lucifer*). The anterior prosternal groove, on the other hand, would be somewhat unusual for this group. This marginal groove is well impressed, and divergent from the margin at the sides, but it does not curve directly back to meet the circumcoxal stria; it meets the pronotal/prosternal suture somewhat anteriorly to it. In appearance this condition is intermediate between the state

observed in *C. setifera* and *C. burnetta*, and that of the rest of the *ectatommae* group. *Chlamydopsis bifovaecollis* (known only from the female holotype) itself is unique among members of the group in having the elytral dorsum smooth rather than reticulopunctate. In body shape, and especially trichome shape, this species and *C. lepida* sp. nov. are otherwise quite similar.

REMARKS. This species was placed originally in *Orectoscelis* 'with some slight doubt' (Oke, 1923). However, despite some general similarity in body shape, this species lacks any of the characteristics of *Orectoscelis* or related genera. Most notably, the scutellum in *bifovaecollis* is fully exposed. The species was reported from near nests of *Euponera lutea* and a small black *Iridomyrmex*, under a log.

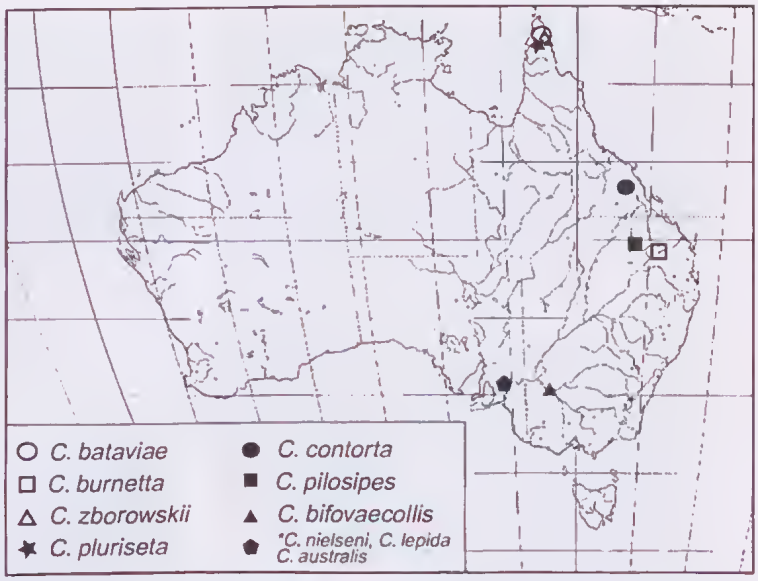

FIG. 18. Collecting records for species of *Chlamydopsis ectatommae* group. The species *C. nielseni*, *C. australis*, and *C. lepida* all share a type locality and are collectively represented by a single point.

Chlamydopsis nielseni sp. nov.
(Figs 16F, 17F, 18)

MATERIAL. HOLOTYPE ♂: 34.21S 139.31E SA, Brookfield Con. Pk., 31 Mar.-29 Apr. 1992, E.S.Nielsen F.I.T. #2; in ANIC.

DIAGNOSIS. This species is the most distinctive of the four placed in this subgroup. It is about 1.5× the size of any of the others, with the body darker and more coarsely sculptured. Its pronotal pits are deeper and located immediately behind the upturned pronotal margin. The humeral trichomes also differ somewhat, with a very limited mesal arc of setae, which themselves are quite elongate, extending downward and then posteriorly for a short distance along the elytral dorsum.

DESCRIPTION. L: 2.46; W: 0.87; E/Pn L: 1.82; E/Pn W: 1.36; Pn W/L: 1.57; E L/W: 0.85; Pr/Py: 1.05; Sterna: 0.75, 0.12, 0.81; Tibiae: 0.97, 1.03, 1.09. Body subquadrate, nearly black, very slightly rufescent, reticulostrigose throughout. Frons about as wide as long, sides rounded, surface reticulate, glabrous, apical margin slightly rounded; labrum arcuate; antennal scapes widest near middle, slightly narrowed to rounded apex, reticulate, glabrous; antennal club retracted (full length not visible).

Prothorax 1.7× as wide as median length; sides margined, sinuate, shorter, ending anteriorly where anterolateral margin is strongly elevated above antennal fossae; anterolateral margin oblique, arcuate, interrupted near sides by groove extending from edge of antennal fossa to a very conspicuous anterolateral pronotal pit, this pit about half the diameter of the exposed antennal fossa (in dorsal view), and immediately behind the raised anterolateral margin; medial portion of pronotal margin elevated less strongly than lateral portions, but not separated from them; pronotal disk depressed anteromedially and posterorly from pits, otherwise broadly convex, subacute at middle.

Prosternum with anterior margin strongly grooved, sinuate, acutely projecting on either side, the anterior groove curving posteriorly at sides joining circumcoxal stria; prosternal keel narrowed and elevated posteriorly, emarginate at apex; entire disk finely reticulate.

Elytra about 1.5× pronotal width, parallel sided, narrowed to base and apex; convex in apical two-thirds, flat to slightly depressed in basal third between humeral trichomes; trichomes widely separated, only slightly elevated, subacute, with an apical bundle of

elongate setae which descend the posteromedial edge of elevation, then curving posteriorly where they meet the elytral surface; anterior aspect of trichome with fine superficial groove arising inward about one-eighth from lateral corner, extending to the apex of the trichome at the base of the setal bundle; elytral surface entirely reticulostrigose, mostly glabrous with a few short setae near apex.

Mesosternum short (<1/8 median length of metasternum) with anterior margin projecting at middle, disk reticulate; mesometasternal suture strongly impressed at sides but not at middle; metasternal disk with single row of punctures along anterior and posterior margins, but disk otherwise impunctate, strongly convex ('raised' relative to metasternum and abdominal sternites); 1st visible abdominal sternite punctate along anterior margin, more sparsely so behind. Legs slender and moderately elongate; profemur shallowly punctate on lower surface, tibiae, and meso- and metafemora with distinct microsculpture but impunctate; outer margin of protibia angulate near basal one-third; meso- and metatibiae bluntly angulate.

Propygidium about one fourth longer than pygidium, slightly depressed along basal margin, but mostly strongly convex; pygidium flat at sides, weakly convex at middle; propygidium and pygidium uniformly reticulate, with sparse, short setae.

REMARKS. It must be noted that this and the following two closely related species were all collected at virtually the same locality, and some share sampling dates as well. This species and the following are both known from males only, while *C. lepida* sp. nov. is known only from females. It is conceivable that some of these should be paired up (*C. australis* sp. nov. and *C. lepida* are the most similar), but this cannot be determined with available material. The species is named in honour of the late Ebbe Nielsen, collector of the type, and noted lepidopterist and biodiversity advocate.

Chlamydopsis australis sp. nov.
(Figs 16G, 17G, 18)

MATERIAL. HOLOTYPE ♂: 34.19S 139.30E SA, Brookfield Con. Pk., 20 Feb.-31 Mar. 1992, A.Calder, W.Dressler, F.I.T. #1; in ANIC.

DIAGNOSIS. This species' elytral strigosity is sufficient to distinguish it from *C. bifovaecollis*. The shape and size of the humeral trichome will separate it from *C. lepida* sp. nov., below. Those of the present species are much smaller, in fact rather inconspicuous from above, while those of *C. lepida* are prominent, occupying much of the outer half of the anterior one-third of each elytron.

DESCRIPTION (compared to the preceding, fully described, species). L: 1.78; W: 0.62; E/Pn L: 1.85; E/Pn W: 1.39; Pn W/L: 1.55; E L/W: 0.86; Pr/Py: 1.23; Sterna: 0.50, 0.09, 0.59; Tibiae: 0.65, 0.65, 0.72. Body lighter, rufescent, more elongate, body more rounded, most surfaces with very fine sparse setae; antennal club visible, about 1.5× length of scape; pronotum very different, groove from antennal fossa to pronotal pit well defined, delimiting rather than interupting the anterolateral portion of pronotal margin; pronotal pit oblong, situated at middle of pronotal side, near margin (posterolaterally relative to that of *C. nielseni*), with lateral pronotal margin elevated and slightly curved around its outer edge; medial portion of anterior pronotal margin not elevated; pronotal disk depressed near posterior margin, but posterior margin itself raised, carinate, especially towards sides; middle of pronotal disk simply convex, not subacutely projecting. Prosternal keel not elevated relative to mesosternum, slightly depressed between procoxae; metasternum and 1st abdominal sternite distinctly microsculptured throughout. Elytra about one-third wider than pronotum, with sides slightly arcuate; humeral trichomes situated more medially, very weakly elevated, with semicircular dorsal opening, the mesal fringe of setae directed downward, partially obscuring cavity beneath; depression between trichomes with blunt postscutellar protuberance; elytral surface entirely reticulostrigose, with uniform microsculpture. Legs shorter, broader; outer margins of tibiae angulate about one-fourth from base. Propygidium uniformly reticulate and with uniform microsculpture; pygidium reticulate only in basal one-fourth, microsculptured throughout.

REMARKS. The name of this species refers to the southerly position of the type locality.

Chlamydopsis lepida sp. nov.
(Figs 16H, 17H, 18)

MATERIAL. HOLOTYPE ♀: 34.19S 139.30E SA, Brookfield Con. Pk., 3 Jun.-28 Aug.1993, S. Williams, F.I.T. #1; in ANIC. PARATYPE ♀: SA: 34.21S 139.31E, Brookfield Con. Pk., 31.iii-29.iv.1992, EN, FIT; in ANIC.

DIAGNOSIS. See diagnoses for *C. bifovaecollis* and the preceding species.

DESCRIPTION. L: 1.68; W: 0.62; E/Pn L: 1.70; E/Pn W: 1.43; Pn W/L: 1.50; E L/W: 0.79; Pr/Py: 1.14; Sterna: 0.44, 0.09, 0.53; Tibiae: 0.53, 0.56, 0.62. As mentioned above, this speeies possibly represents the female of the preeeding speeies. The two differ substantially in triehome shape, with those of *C. lepida* mueh larger (Figs 16G, H). The elytral dises are also less strongly strigose in the present speeies (a frequent sexual differenee in *Chlamydopsis*), the setae of pronotum and elytra, although fine, are more conspieuously seale-like, and the overall body size is slightly smaller. Otherwise , the two are very similar. An additional feature worth noting is the antennal club. Its outer surfaces are largely selerotised, with only the oblique apex and a smaller subapieal pateh tomentose.

REMARKS. The name of this speeies refers to its seale-like dorsal setae.

EPIPLEURALIS GROUP

The *epipleuralis* group is a rather heterogeneous group of mainly temperate speeies. The group is primarily charaeterised by triehome charaeters. The setal fringes of both anterior and posterior humeral elevations tend to have separate inner and outer origins. The inner and outer origins of the anterior elevation are divided at the entry point of the anterior humeral groove. In most speeies the inner apiees of anterior and posterior humeral elevations nearly meet, with their respeetive setal fringes opposing and separating the mediobasal elytral depression from a dorsally open, rounded lateral eavity. The setal fringe of this lateral eavity may be continuous, interrupted at an epipleural ineision, or, rarely, absent. All members of this group have a well developed anterior marginal prosternal groove that departs from the margin laterally to meet the eireumeoxal stria. Most also have the anterior and lateral margins of the pronotum strongly elevated. This group eontains several of the largest known *Chlamydopsis* speeies.

Chlamydopsis epipleuralis Lea, 1912
(Figs 16I 17I, 21, 30A)

Chlamydopsis epipleuralis Lea, 1912: 68; MATERIAL. HOLOTYPE: epipleuralis Lea Type, Hornsby/ 14673 *Chlamydopsis* epipleuralis N. S. Wales, Type; mounted with two host ants; SAM, examined.
Chlamydopsis epipleuralis var. *mastersi* Lea, 1912: 68; Mazur, 1984: 110.

RECORDS. NHM: NSW: Sydney; Vie: Ballarat; SA: Mt Lofty Rep. (mounted w. id'd *Iridomyrmex anceps*), SA: Adelaide. WAM: NSW: Sydney. QMB: NSW: Sydney. AMS: NSW: Sydney; NSW: Como, June. MCZ: WA: Swan River [has two labels on pin (whieh has two specimens)] other says NSW: Sydney, more likely. Lea (1925): Vie: Sea Lake; WA: Perth 'a small species of *Iridomyrmex*'. Oke (1923): Vie: Whittlesea, with *Iridomyrmex gracilis*.

DIAGNOSIS. L: 2.43; W: 0.90; E/Pn L: 1.69; E/Pn W: 1.30; Pn W/L: 1.48; E L/W: 0.88; Pr/Py: 1.15; Sterna: 0.59, 0.22, 0.69; Tibiae: 1.03, 1.18, 1.31. *Chlamydopsis epipleuralis* is one of the most common and widespread speeies of the group. It is very elosely related to *C. sculptus* Oke, and the two are diffieult to separate. Together they are most easily reeognised by the form of the humeral triehome. The anterior surfaee is nearly flat, and ineised by a moderately deep, straight superfieial groove. The inner anterior and posterior elevations of the triehomes nearly meet, and are pointed apieally so as to meet at opposing, setose triangular faees. Lateral to these inner elevations is a nearly eireular opening, setose on at least its anterior (and often the entire) edge. *Chlamydopsis convexa* is somewhat similar to these in its general triehome shape. But its anterior superfieial humeral groove is displaeed laterally, with the anterior triehome elevation strongly eonvex mesal to the groove, and the outer eireular opening of the triehome laeks setae. *Chlamydopsis epipleuralis* and *C. sculptus* differ from eaeh other mainly in pronotal sculpture, with the punetures of *epipleuralis* extremely shallowly impressed, those of *sculptus* being mueh more eonspieuous, and even with intermingled finer punetures. The triehomes also differ slightly, most noticably in the anterior superfieial groove, whieh has its outer edge earinate and distinet in *epipleuralis*, but rounded, indistinet in *C. sculptus*.

REMARKS. Not all of the above speeimens have been studied, and some may refer to *C. sculptus* (below), as several sueh misidentifieations have been found. Oke's (1923) host record of *Iridomyrmex gracilis* refers to a valid speeies, but several subspeeies are now reeognised. The nominate subspeeies, oeeurring in eoastal Victoria, is likely the proper one.

Chlamydopsis sculptus Oke, 1923
(Fig. 21)

Chlamydopsis sculptus Oke, 1923: 158; Lectotype, hereby designated: Maeedon, V[ictoria]., 23.4.21, C.Oke/ *Chlamydopsis sculptus*, Oke. Type/ Presented by C. G. Oke/ 902 Type; MVM, examined, 2000. Paraleetotype, hereby designated: Bendigo, V, 1.10.21, C.Oke/ *Chlamydopsis sculptus*, Oke. Co-Type/ 903 Paratype; AMS. An additional speeimen of this speeies was found bearing a type label Bendigo, 4.10.24 [Vie]. However, the

collection apparently postdates the description, and the type label should be disregarded.

RECORDS. SAM: SA: 13km E Marion Bay, Yorke Pen. 6.xi.1981, pitfall trap behind beach. WAM: Vic: Bendigo, Sept and Oct. QMB: SA. ANIC: SA. AMS: Vic: Ballarat, Vic: Maldon; SA: Adelaide. USNM: SA: Lucindale. Oke (1923): all Vic: Sea Lake; Daylesford; Ballarat; SA: Mount Lofty.

DIAGNOSIS. L: 2.55; W: 1.00; E/Pn L: 1.56; E/Pn W: 1.30; Pn W/L: 1.38; E L/W: 0.88; Pr/Py: 1.26; Sterna: 0.69, 0.19, 0.78; Tibiae: 1.0, 1.0, 1.12. See diagnosis under *C. epipleuralis*, above.

REMARKS. Reported from nests of *Iridomyrmex* sp. (Oke, 1923).

Chlamydopsis convexa sp. nov.
(Figs 19A, 20A, 21)

MATERIAL. HOLOTYPE ♂: 34.21S 139.31E SA [South Australia] Brookfield Con. Pk. 7 Oct.-7 Nov. 1992, J. Stelman, S. Williams, FIT #2/ F.I.T, ANIC 1266, mallee #2; in ANIC. PARATYPES (4): 1 ♂: same data as holotype; 1 ♀: same but 2.xii.91-2.i.1992, FIT, ANIC 1224 mallee #2; 1 ♀: same but 7.xi-24.xi.1992, FIT, ANIC 1268 mallee #2; 1 ♂: SA: 34.19S 139.30E, 20.x-3.xi.1991, E. Edwards, SS, FIT, ANIC 1208 mallee with Triodia #1; in ANIC, MSCC.

DIAGNOSIS. This species is similar to the previous two in general body and trichome shape. The most pronounced difference is that the inner anterior elevation of this species' trichome is uniquely convex (rather than flat) and displaces the anterior superficial groove (and the reduced outer portion of the anterior elevation) laterally. Its body is also somewhat narrower overall. Other differences include: glabrous dorsum, weak to indistinct elytral strigosity, and lack of setae lining the outer opening of the trichome.

DESCRIPTION. L: 2.12; W: 0.78; E/Pn L: 1.72; E/Pn W: 1.23; Pn W/L: 1.60; E L/W: 0.88; Pr/Py: 1.29; Sterna: 0.56, 0.12, 0.65; Tibiae: 0.72, 0.75, 0.78. Body orangeish brown, appearing largely smooth and glabrous; punctures on many surfaces extremely shallow, appearing granulate within; frons about as wide as long, sides parallel at middle, narrowed to base and apex, anterior margin straight , disk nearly flat, glabrous, very sparsely and shallowly punctate; labrum rounded, impunctate with numerous short apical setae; antennal scape with outer margin forming a blunt 90° angle near basal one-third, apex rounded, disk microsculptured and finely setose; antennal club of male 1.2× as long as scape; that of female 0.6× as long a scape.

Pronotum about 1.7× as wide as long, margined laterally, sides weakly outwardly arcuate, widest near middle, distinctly but not strongly elevated; anterior margin elevated, with medial and lateral portions continuous with each other and with elevated pronotal sides; disk convex at middle, with sparse, inconspicuous punctures, separated by slightly more than their widths.

Prosternum with anterior margin deflexed, deeply grooved, sinuate and acutely projecting on either side, marginal groove curving posteriorly at sides and merging with circumcoxal stria; prosternal disk depressed behind anterior margin, narrowed posteriorly; apex of keel shallowly emarginate; prosternal disk faintly punctate, without grooves along the proleg depressions.

Elytra about one-fifth wider than base of pronotum; humeral trichomes prominent; inner edges of anterior and posterior elevations broad, strongly convex, their opposing edges with dense fringes of very short setae, nearly meeting; outer edges of humeral elevations less prominent, displaced laterally, a thin outer wall between them closing the trichome laterally; trichome opening round, its cavity deeper than floor of mediobasal elytral depression; outer edge of rounded opening finely carinate, without setae; anterior humeral groove large, deep, extending from humeral corners to anterior edge of lateral trichome opening; mediobasal depression with setose, blunt, transverse tubercles; elytral disk flat to weakly convex posteriorly, with very fine setae throughout, a few shallow, elongate punctures posteriorly; posterior elytral margin finely carinate, this carina continuous with blunter ridge extending forward to outer edge of trichome; epipleuron strigose, strigae converging to trichome.

Mesosternum short, about 5× as wide as median length, bluntly projecting at middle, more acutely projecting at sides, in front of mesocoxae; disk sparsely punctate and finely setose; mesometasternal suture impressed; median metasternal suture very finely elevated; metasternal disk sparsely and finely punctate; 1st abdominal sternite similar in texture. Legs short, rather broad, impunctate, with minute setae; outer surface of profemur with well developed oblique carina; meso- and especially metafemora with margins arcuate; tibiae angulate at basal one-third; tarsi laterally compressed.

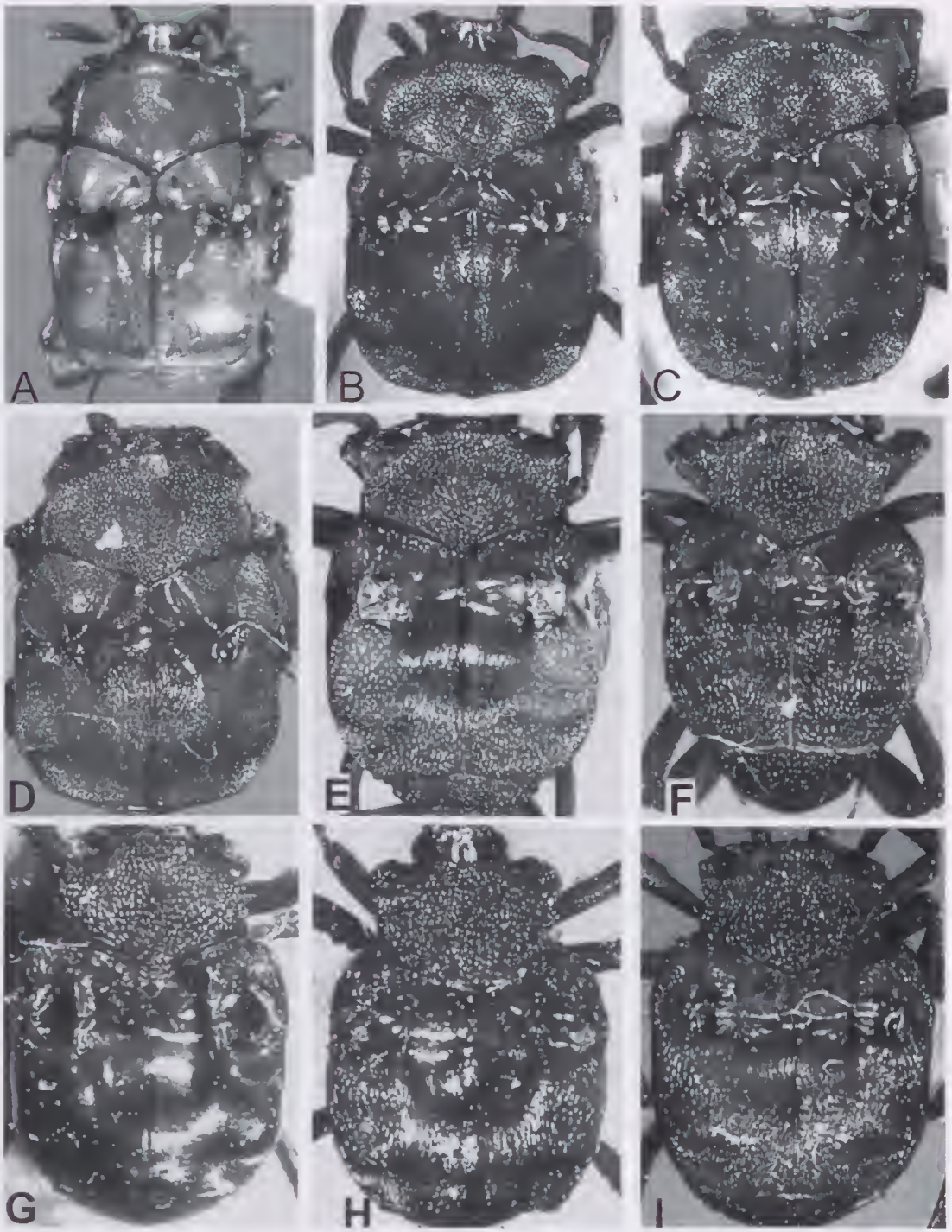

FIG. 19. Dorsal views of *Chlamydopsis* spp. A, *C. convexa*. B, *C. striatella*. C, *C. formicicola*. D, *C. dispersa*. E, *C. weiri*. F, *C. crowcrofti*. G, *C. latipes*. H, *C. macmillani*. I, *C. nullarbor*.

Propygidium about 1.2 × as long as pygidium, shallowly depressed along anterior margin, otherwise evenly convex, with sparse, very shallow punctures, finely setose; pygidium nearly flat, weakly depressed posterolaterally, faintly punctate.

REMARKS. The name of this species refers to the anterior convexity of the humeri.

Chlamydopsis striatella Westwood, 1869 (Figs 19B, 20B, 21)

Chlamydopsis striatella Westwood, 1869: 318; Type locality 'Swan River' [WA]; type specimen not located, sought at Oxford in 2001.

REMARKS. It is extremely unfortunate that the identity of this species, the type of the genus, seems terminally uncertain. Westwood's type specimen seems to be lost. Although the species was illustrated by Westwood, not all diagnostic characters are clearly visible. The only clues we have to the its identity come from a debate in the literature (Lea, 1912, responding to Lewis, 1910). Lewis removed *C. striatella* and *C. formicicola* King from synonymy, and offers characteristics for separating them from each other and from *C. inquilina* Lewis. Lea agreed with removing the two species from synonymy, but goes further to suggest that Lewis is incorrect concerning the identity of *C. striatella*. Lea cited specimens of *C. striatella* from only Western Australian localities (Swan River [1912], and Fremantle [1910]), and apparently bases his identification on the fact that Swan River is the published type locality of *C. striatella*. Lewis's *C. striatella*, on the other hand, has only been reported from the southeastern part of the continent. Geography would seem to favor Lea's concept. However, I have studied specimens from both authors' collections, and Lewis's determination (as a species close to *C. formicicola*) is a much better match to Westwood's figure than is Lea's determination; the Fremantle specimen cited above, housed at SAM, though lacking prothorax and head is identifiable as a member of the *ectatommae* species group, and shares no obvious similarities with Westwood's figure. Ultimately, as neither author makes reference to having studied a type of any kind, this identity may be unknowable. But for the present, Lewis's conception is considered more likely correct. That being said, I have been unable to discern any differences between Lewis's specimens of *C. striatella* and *C. formicicola* King (and cite his specimens under the latter species).

RECORDS (assuming the identity asserted above holds). WAM: NSW: Tahmoor.

Chlamydopsis formicicola (King, 1869) (Figs 19C, 20C, 21)

Chlamydopsis formicicola King, 1869: 74; Lectotype, hereby designated: *Byzenia formicicola* RLK, ants nests, Liverpool, NSW./ K26343; AMS, examined, 2001; 2 paralectotypes, same data as type; AMS.

Chlamydopsis formicicola var. *darwinensis* Lea, 1918: 85; Mazur, 1984: 110.

RECORDS. NHM: NSW: Glen Jones, 14.vii.1921; NSW: Sydney. AMS: NSW: Sydney; NSW: Liverpool. QMB: 23°32'S 147°18'E, Bogantungan, 13.5km N, 26.x-17.xii.2000, 880m, DC & GM, Ironbark woodland, FIT, 9825. Lea (1925): nests of *Camponotus aeneopilosus*, Brooklyn, Hawkesbury River [both NSW]. Oke (1923): Vic: Sea Lake; Vic: Bendigo.

DIAGNOSIS. L: 2.74; W: 1.00; E/Pn L: 1.75; E/Pn W: 1.13; Pn W/L: 1.66; E L/W: 0.93; Pr/Py: 1.10; Sterna: 0.69, 0.16, 0.75; Tibiae: 1.06, 1.21, 1.40. This species is similar and closely related to *C. dispersa* sp. nov., described in full below. The most diagnostic difference is in the shape of the humeral trichome. In *C. formicicola*, its dorsal opening is larger, occupying most of the apex of each elevation (rather than just the inner half). The anterior superficial groove is deeper, and the anterior surface of the elevation is flat on each side of this groove, and shallowly inclined toward it. A small tubercle present in this groove in *C. dispersa* is not evident in *C. formicicola*. In addition the pronotal disk of *formicicola* is less densely punctate, although the punctation is still rather dense, and the apices of the elytra are fringed with setae. (In the Queensland specimen, much of the body is sparsely setose; other specimens are otherwise bare).

REMARKS. King (1869) originally described this species in the Byrrhidae. The reported host, *Camponotus aeneopilosus* remains a valid species, but with two subspecies, both apparently within the range of *C. formicicola*. There is some possibility that the following species represents the male of *C. formicicola*; see Remarks below.

Chlamydopsis dispersa sp. nov. (Figs 19D, 20D, 21, 29G)

MATERIAL. HOLOTYPE ♂: 12.48S, 132.42E, Nourlangie Ck, 8km N. of Mt Cahill, N.T., 19.xi.1972, M.S.Upton; in ANIC. PARATYPES (13): 1 ex.: same data as holotype; 1: same but 26.x.72, at light, E.B. Britton; 2 ex.: NT: 12.47S, 132.51E, 19km NE. by E. of Mt Cahill, 16.xi.1972, MU; 1: NEQ: 23km E. of Mareeba (Kanervo Rd), 29.i.1989, A. Howden, at light; 1 ex.: NEQ: Mt Spec, i.69; 2 ex.: NT: Tindal, 14.31 S 132.22E, 1-20.xii.1967,

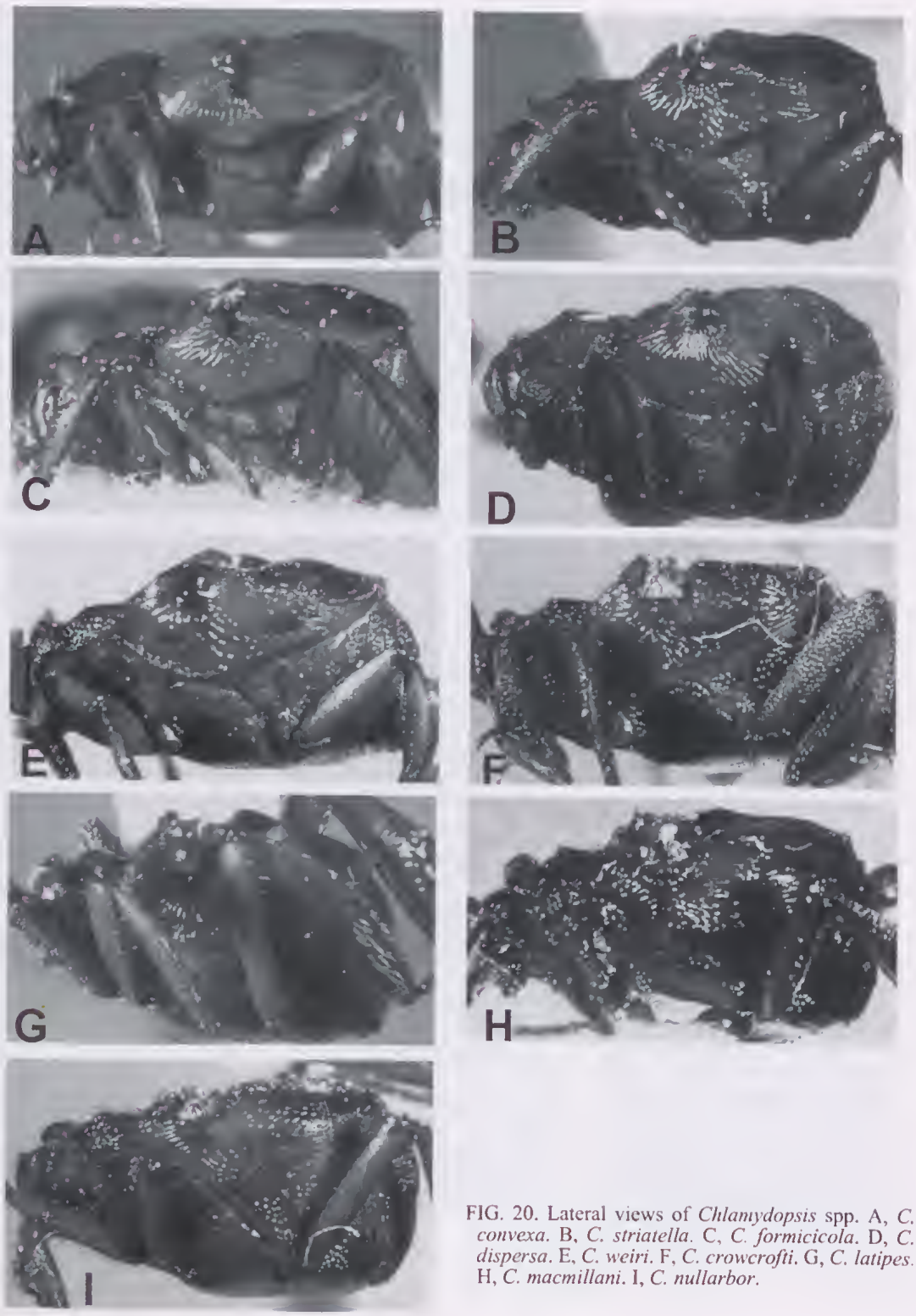

FIG. 20. Lateral views of *Chlamydopsis* spp. A, *C. convexa*. B, *C. striatella*. C, *C. formicicola*. D, *C. dispersa*. E, *C. weiri*. F, *C. crowcrofti*. G, *C. latipes*. H, *C. macmillani*. I, *C. nullarbor*.

light trap, W.J.M.Vestjens; 1 ex.: NT: 16.28S 136.09E, 46km SSW of Borroloola, 28.x.1975, MU; 1 ex.: NT: Muriella Park, Kakadu, 18.v.1987, Fay & KH, at UV light; 1 ex.: NT: Kakadu NP, S. Alligator R., Gungaree RF, 17.xii.1993, uv light, S&J Peck; 1 ex.: NT: Kakadu NP, North Point, RF FIT, 24.xii-7.i.1993, S&J Peck; 1 ex.: N. Qld: Edungalba, 14.xii.1988, H&A Howden; in ANIC, DPIM, QMB, CMN, MSCC.

DIAGNOSIS. See under *C. formicicola*, above.

DESCRIPTION. L: 2.68; W: 1.03; E/Pn L: 1.61; E/Pn W: 1.19; Pn W/L: 1.58; E L/W: 0.85; Pr/Py: 1.26; Sterna: 0.75, 0.16, 0.81; Tibiae: 1.03, 1.15, 1.31. Body dark rufescent, subquadrate; most surfaces densely punctate, with dense microsculpture between punctures; frons about 1.2× as long as wide, sides nearly straight, narrowed abruptly at antennal insertions and gradually to apex; clypeolabral suture straight; disk densely punctate, with both large and intermingled smaller punctures, ground texture between punctures somewhat granulate; labrum rounded; antennal scapes widest about one-third from base, abruptly narrowed to base, gradually narrowed to rounded apex; antennal club of male 1.5× as long as scape.

Prothorax about 1.5× as wide as long, sides margined, widening slightly towards front; anterior pronotal margin strongly elevated, tripartite, with the lateral portions angled back obliquely from transverse medial portion, lateral portions slightly arcuate; pronotal disk strongly depressed behind anterior margin, convex in posterior half, strongly elevated, subacute at middle; disk densely and uniformly punctate, the punctures somewhat convergent toward scutellum.

Prosternum with anterior margin strongly grooved, this groove curving posteriorly at sides and continuous with circumcoxal stria; anterior margin slightly deflexed, sinuate, acutely projecting on each side of middle; prosternal keel narrowed posteriorly, acutely emarginate at apex; prosternal disk densely punctate throughout.

Elytra together about as wide as long, sides rounded, widest behind middle; humeral trichomes prominent, occupying outer two-thirds of each elytron; anterior elevation broadly raised, anterior surface transversely concave, with oblique superficial groove from anterolateral corner; superficial groove with very small tubercle anterior to where the groove widens around mesal opening of trichome; mesal opening nearly circular, with setose fringe which continues straight down inner edges of anterior and posterior elevations; trichome with conspicuous lateral notch as well, this (in lateral view) bent obliquely posterad; outer edge of posterior elevation continuous with low marginal carina which continuous around posterior elytral margin; elytral disk strongly depressed between trichomes, impunctate within depression, with low arcuate carina from elytral suture to base of trichome opening; disk elsewhere densely punctate (strigose near middle) and microsculptured in the intervening space, except smooth on trichome elevations, particular the anterior.

Mesosternum about 3× as wide as median length, anterior margin sinuate, projecting medially; anterior and lateral margins subcarinate; disk raised along longitudinal midline, finely but densely punctate; mesometasternal suture impressed; metasternum convex, with small punctures separated by slightly more than their widths throughout, but denser along midline and posteriorly; 1st visible abdominal sternite densely punctate anteriorly, more sparsely so posteriorly, the more posterior punctures each bearing minute seta; legs slender, elongate; pro- and mesotibiae bluntly angulate about one-third from base; metatibial margin simply rounded; outer surfaces of all legs more or less uniformly covered with setigerous punctures, the tibiae more finely microsculptured toward outer margins.

Propygidium about one-third longer than pygidium along midline, weakly depressed along anterior margin, otherwise strongly convex; pygidium flat to slightly convex; propygidium and basal half of pygidium densely punctate and microsculptured, the apical half of pygidium very sparsely punctate.

REMARKS. The two Queensland specimens of this species are markedly broader than those from Northern Territories, but differ in no other obvious characters. The entire type series consists of males, while, where checked, the few *C. formicicola* specimens examined have all been females. Their known distributions nearly abut in central Queensland, prompting the possibility that the two species are sexes of the same species. However, the differences between them would not correspond to any other known *Chlamydopsis* dimorphisms. The name of this species alludes to its relatively broad distribution.

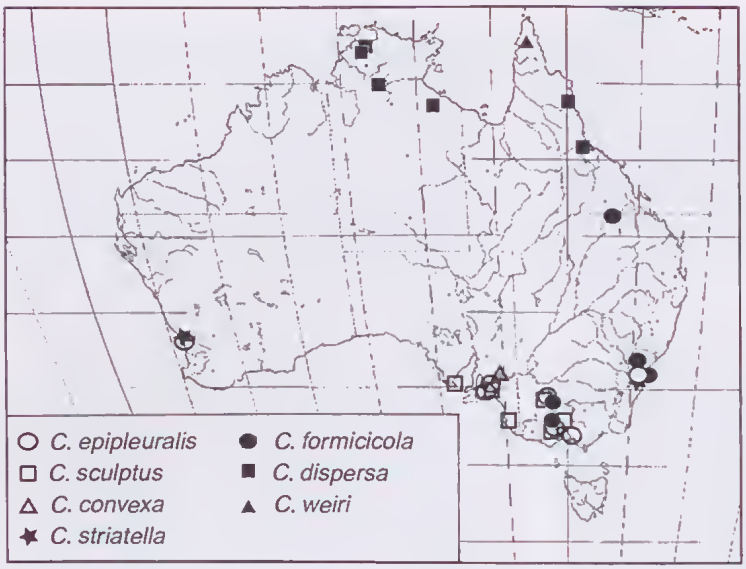

FIG. 21. Collecting records for species of *Chlamydopsis epipleuralis* group.

Chlamydopsis weiri sp. nov.
(Figs 19E, 20E, 21)

MATERIAL. HOLOTYPE ♂: 12.39S142.42E Qld,4km NE Batavia Dns. 16Sept.-24Oct.1992, FIT, P.Zborowski & T.Weir; in ANIC.

DIAGNOSIS. This species is similar to the preceding two, sharing an upturned anterior (but not lateral) pronotal margin and fairly simple, rounded, mesally open trichomes, the anterior elevations of which are broad and more or less flat. The outer border of the trichome opening is subacutely elevated in the present species, and smooth on its outer surface, whereas in the preceding two, while the trichome is closed laterally, a shallow groove extends latcrad from the trichome opening to a deep epipleural invagination.

DESCRIPTION. L: 2.62; W: 0.97; E/Pn L: 1.71; E/Pn W: 1.28; Pn W/L: 1.61; E L/W: 0.83; Pr/Py: 1.17; Sterna: 0.75, 0.16, 0.87; Tibiae: 0.97, 1.06, 1.18. Body rufescent brown; frons slightly wider than long, with sides broadly arcuate, slightly elevated relative to disk, acutely projecting near antennal insertions, disk coarsely reticulopunctate, glabrous; apical frontal margin shallowly emarginate; labrum rounded, shallowly punctate, with numerous very short setae along apical margin; antennal scapes strongly angulate one-third from base, basal portion of outer margin inwardly arcuate, apical portion mostly straight, narrowed to rounded apex; antennal club of male about 1.5× as long as scape.

Pronotum 1.75× as wide as long, narrowest at base, widening slightly to intersection with lateral portions of anterior pronotal margin; sides margined, disk slightly depressed along margin; anterior margin strongly elevated, the medial portion interrupted by a notch at middle and at sides; lateral portions projecting forward slightly beyond medial portion, arcuate to sides; disk convex, with very short, faint transverse median carina densely punctatostrigose, with minute setae interspersed, the strigae converging toward scutellum.

Prosternum with anterior margin deflexed, deeply grooved, sinuate and bluntly projecting on either side of middle, the marginal groove curving posteriorly at sides and merging with circumcoxal stria; prosternal disk transversely depressed behind anterior margin, and somewhat longitudinally depressed between procoxae; edge of proleg depression strongly carinate, and with deep groove along inner margin of this carina from apex of keel around to sides; keel narrowest between procoxae, slightly widened to apex, emarginate apically; prosternal disk densely punctate throughout.

Elytra about 1.4× as wide as base of pronotum, sides more or less parallel, evenly narrowed to base and apex; humeri strongly elevated, particularly at sides, with lateral 'wall' slightly overhanging trichome opening; trichome open mesally, anterior and posterior edges parallel, outer edge more rounded, lined with nearly continuous fringe of setae (though anterior, lateral, and posterior fringes are interrupted underneath overhanging side), those of the inner anterior corner and outer edge longest; anterior humeral grooves, nearly straight, extending from humeral corner to anterolateral corner of trichome opening; mediobasal elytral depression occupying slightly less than basal half, smooth, with prominent, arcuate, transverse carinae; elytral disk outside of depression densely punctatostrigose, slightly elevated near posterolateral corners; apical elytral margin

carinate, carina diverging from margin at sides, and extending forward about one-fourth of elytral length.

Mesosternum about 4 × as wide as long, raised along midline, depressed at sides, acutely projecting at middle, disk punctate; meso-metasternal suture strongly impressed, crenulate, continuous at sides with postmesocoxal line; longitudinal metasternal suture shallowly impressed, complete; metasternal disk uniformly but sparsely covered with small punctures, interstices microsculptured, faintly alutaceous; 1st abdominal sternite similarly sculptured, though punctures smaller. All legs short, slender; tibiae angulate near basal one-third; outer surfaces of profemur and tibia sparsely punctate, meso- and metafemora and tibiae with smaller punctures, most with minute setae.

Propygidium depressed along anterior margin, strongly convex along midline, depressed at sides, disk coarsely reticulopunctate; pygidium slightly convex, densely punctate in basal one-half, more sparsely apically.

REMARKS. This species is named in honour of Tom Weir, who collected the type and has offered considerable assistance during this study.

Chlamydopsis crowcrofti sp. nov.
(Figs 19F, 20F, 24)

MATERIAL. HOLOTYPE ♂: 34.21S 139.31E SA, Brookfield Con. Pk., 12 Sept.-20 Oct. 1991, J.Stelman, S.Williams, F.I.T.#2/ F.I.T. ANIC 1206 mallee #2; in ANIC. PARATYPE: 1 ♂: same data as holotype but 7.x-7.xi.1992; in ANIC.

DIAGNOSIS. This and the following five species form a relatively distinctive grouping (referred to here informally as the '*latipes* subgroup'), united by humeral trichome shape. In all the inner edges of the anterior and posterior elevations of each trichome are well separated from each other, but have opposing bundles of setae which nearly or actually touch, while laterally the trichome is flat, broadly rounded, bearing an arc of marginal setae projecting mesally above an internal 'shelf', which variously conceals the opening of the trichome. In addition, all have the pronotum at least slightly acutely tuberculate, the anterior pronotal margin (but not the lateral) elevated, and metatibiae moderately to markedly elongate. The present species is distinguished from the others principally by the form of the anterior superficial groove of the trichome, which is slightly 'undercut' toward the outside, such that the outer edge of the groove is strongly carinate, while its inner edge is nearly flat and noncarinate. The sparse dorsal setae are more conspicuous, particularly on the posterior portions of the elytra, than in any other species in this group.

DESCRIPTION. L: 2.71; W: 1.00; E/Pn L: 1.72; E/Pn W: 1.26; Pn W/L: 1.78; E L/W: 0.76; Pr/Py: 1.24; Sterna: 0.78, 0.28, 0.93; Tibiae: 1.21, 1.43, 1.74. Body rufescent, somewhat rounded, almost entirely densely reticulately punctate, with sparse, elongate setae throughout; frons about as long as wide; sides rounded, gradually narrowed to apex, abruptly narrowed at antennal bases; apical margin very slightly sinuate; frontal disk reticulate, bearing ~5 irregularly placed long setae; labrum rounded, nearly semicircular, reticulate, with anterior fringe of shorter setae; outer basal surfaces of mandibles reticulate; antennal scape with inner margin arcuate, outer margin angulate, widest about one-third from base, reticulate; antennal club of male 1.3 × as long as scape.

Prothorax 1.5 × as wide (at base) as median length; sides margined, parallel in basal two-thirds, abruptly widened in apical third. with sparse setal fringe; anterior pronotal margin strongly elevated, the lateral thirds arcuate, oblique to medial third and slightly projecting forward of it where they meet; median portion not quite as high as lateral, distinctly notched at middle; pronotal disk shallowly depressed behind anterior margin, convex posteriorly, weakly acutely produced at middle; disk entirely reticulopunctate, the posteromedial reticulae slightly more elongate, converging toward scutellum; disk with sparse elongate, though mainly decumbent, setae.

Prosternum with anterior margin deflexed, deeply grooved, sinuate and bluntly projecting on either side of middle, the marginal groove curving posteriorly at sides and merging with circumcoxal stria; prosternal disk transversely depressed behind anterior margin, convex posteriorly between procoxae; prosternal keel narrowed to between coxae, then slightly widened to apex, apex deeply emarginate; entire prosternal disk reticulate.

Elytra approximately 1.5 × wider than base of prothorax; sides of elytra slightly sinuate, slightly wider anteriorly, rounded to apex; humeral trichomes prominent, their openings nearly circular, broadly open mesally (and beneath), with a lateral arc of dense, erect setae, and separate opposing dense bunches of setae on the

inner edges of the posterior and anterior elevations; shelf above opening where lateral trichomal setae are inserted open in lateral view; anterior elevation subacutely produced, with deep, almost straight superficial groove extending from anterolateral elytral corner to outer edge of trichome opening, this groove slightly undercut toward the outside such that its outer edge is overhanging; basal elytral depression with two arcuate carinae from elytral suture behind scutellum to anterior edge of opening of trichome; posterior half of elytra unevenly convex, surface undulated in posterolateral corners; posterior elytral margins carinate, these carinae diverging from margin at posterolateral corners and extending about one-fifth around the side before diminishing.

Mesosternum about 3× as wide as median length; anterior margin sinuate, projecting at middle; mesosternal disk depressed in anterior corners, elevated at middle, uniformly reticulate; mesometasternal suture crenulately impressed; metasternum only very sparsely and finely punctate, with faint alutaceous microsculpture; postmesofemoral line ending short of metepisternum; 1st visible abdominal sternite with conspicuous row of small punctures along anterior margin, but more sparsely punctate behind; postmetafemoral line not well developed, ending behind coxa; femora widened to apex, exposed surfaces densely punctate, with setae along anterior and posterior margin; protibia slender, angulate about one-third from base, densely punctate on outer surface, approximately equal in length to profemur; meso- and especially metatibiae conspicuously (about one-sixth in the latter case) longer than their respective femora, widened, with dense punctures only along edges; mesotibia angulate one-third from base; metatibia rounded, only bluntly angulate near middle.

Propygidium 1.3× longer than pygidium, slightly depressed along anterior margin, otherwise strongly convex, reticulopunctate, sparsely setose; pygidium convex, densely punctate in basal half, punctures slightly more widely spaced in most of apical half.

REMARKS. This species is named for renowned mammologist Peter Crowcroft, in recognition of his role in establishing Brookfield Conservation Park, type locality of this and several other *Chlamydopsis* species. Although his primary concern at the time was the southern hairy nosed wombat (*Lasiorhinus latifrons*), numerous additional species benefit from his efforts.

Chlamydopsis latipes Lea, 1919
(Figs 19G, 20G, 24)

Chlamydopsis latipes Lea, 1919: 176; HOLOTYPE ♀: *latipes* Lea Type, Mt Henry/ *Chlamydopsis latipes* Lea, W. Australia Type, 10675; mounted with 2 hosts, reportedly *Dolichoderus (Hypoclinea) scabridus* (Lea, 1919); SAM, examined, 2000.

MATERIAL. WAM: WA: Chidlow's Well [31°86'S, 116°26'E], 22.v.1953, in association with *R[hytidiponera] convexa*, under stone very dull day, quiescent in gallery, East aspect. Lea (1925): WA: Armadale [32°09'E, 116°00'S], *Rhytidoponera convexa violacea*.

DIAGNOSIS. L: 3.61; W: 1.40; E/Pn L: 1.58; E/Pn W: 1.59; Pn W/L: 1.29; E L/W: 0.77; Pr/Py: 1.19; Sterna: 0.93, 0.37, 1.21; Tibiae: 1.74, 2.12, 2.55. See above to diagnose the *latipes* subgroup. Within this group *C. latipes* itself is unique in having the elytra behind the trichomes virtually impunctate. While faint strigosity is detectable, it is inconspicuous at lower magnifications. However, apart from this character and its larger body size, *C. latipes* is very similar to the following, and there is a chance that they are sexes of the same species. There is precedent for this sort of dimorphism within *Chlamydopsis* (see *strigicollis* group above). But the two are known from no identical localities, and from too few specimens to be able to do more than suggest their identity.

REMARKS. As currently delimited, the ant *Dolichoderus scabridus* does not occur in Western Australia. This host record may refer to what is now called *D. ypsilon ypsilon*, a Western Australian species with *D. scabridus ypsilon* as a synonym. Interestingly this species and the hosts of the nontype records are in different formicid subfamilies.

Chlamydopsis macmillani sp. nov.
(Figs 19H, 20H, 24)

MATERIAL. HOLOTYPE ♂: Perth, John Forrest National Park, Darling Range, Western Australia, Sept. 1974, G.H. Lowe/ in nest of *Rhytidoponera violaceum* – in midst of ants/ Western Australian Museum Entomology Reg no. 27236/ *Chlamydopsis*, is close to *C. latipes*, Det. R.P. McMillan; in WAM.

DIAGNOSIS. See above for group diagnosis of the *latipes* subgroup. This species is distinguished by having the lateral portion of the humeral trichome broadly rounded, and with relatively inconspicuous internal shelf, such that

nearly the entire lumen of the trichome is visible from above. The smaller size and reticulostrigose elytra of *C. macmillani* distinguish it from *C. latipes*. Its evenly impressed superficial humeral groove, and glabrous pygidium and posterior elytral disks distinguish it from *C. crowcrofti*.

DESCRIPTION. L: 2.83; W: 1.06; E/Pn L: 1.68; E/Pn W: 1.47; Pn W/L: 1.50; E L/W: 0.76; Pr/Py: 1.09; Sterna: 0.78, 0.28, 1.00; Tibiae: 1.37, 1.46, 1.81. As for *C. crowcrofti*, above, except: dorsum with few setae on pronotal disk, lateral pronotal margins, and on anterior surfaces of humeri, otherwise glabrous; sides of pronotum inwardly arcuate, nearly as wide at apex as at base. Humeral trichomes with openings C-shaped, open mesally, with opposing dense bundles of short setae closing the 'C', outer fringe of setae occupying most of lateral arc, with arcuate groove above and lateral to fringe, and short, inconspicuous inner shelf beneath it; floor of trichome lumen smooth, glabrous, continuous between trichomes; superficial humeral groove of humeral trichome evenly incised, with inner and outer edges carinate. Metasternal disk with sparse but conspicuous small punctures, these denser along posterior half of longitudinal metasternal suture; punctures of 1st visible abdominal sternite not appreciably concentrated along anterior margin, but fairly evenly distributed, separated by 1-2× their widths; meso- and metatibiae not longer than their respective femora, outer meso- and metatibial punctures largely confined to basal one-third of their lateral margins. Propygidium and pygidium glabrous.

REMARKS. This species is named in honor of Peter McMillan, a long-time chlamydopsine collector and enthusiast, who recognised that this species was undescribed.

Chlamydopsis nullarbor sp. nov.
(Figs 19I, 20I, 24, 29F)

MATERIAL. HOLOTYPE ♂: 32.08S 126.18E, 23km ESE of Cocklebiddy WA, 25.x.1977, J.F.Lawrence/ berlesed from leaf litter; in ANIC.

DIAGNOSIS. This member of the *latipes* subgroup is most easily distinguished by characters of the humeral trichome. The lateral arc of setae arises in a discrete single row, with conspicuous flat, impunctate shelves both mesal and lateral to it. Approximately the outer half of the lumen of the trichome is obscured by this inner shelf, but no carina arises from the transverse elytral depression to close the lumen medially (as is the case in the following two species). The most similar known species is *C. latipes*, which may be immediately distinguished by its impunctate elytra.

DESCRIPTION. L: 3.18; W: 1.15; E/Pn L: 1.76; E/Pn W: 1.52; Pn W/L: 1.51; E L/W: 0.76; Pr/Py: 1.19; Sterna: 0.93, 0.34, 1.18; Tibiae: 1.50, 1.65, 2.02. As for *C. crowcrofti*, above, except: Posterior half of elytra, and propygidium and pygidium lacking setae: pronotum barely notched at middle; most setae of pronotum actually bundles of two setae; humeral trichome broadly rounded, slightly narrowed mesally, with anterior and posterior bundles of mesal setae meeting; outer arc of setae projecting inward above curved shelf, concealing slightly more than outer half of lumen of trichome; also with impunctate shelf outside of outer setal arc, delimited laterally by an elevated outer margin; transverse basal elytral depression glabrous across middle, with a few punctures beneath inner edge of trichome opening; posterior half of elytral disk reticulostrigose; metasternal disk evenly punctate along anterior and posterior margins, and along median longitudinal suture, lateral portions of disk much more sparely and finely punctate; 1st visible abdominal sternite sparsely punctate at middle, more densely so towards metacoxae; pygidial punctures smaller but no less dense toward apex.

REMARKS. This species name is the region of the type locality. Latin reference to the lack of tall trees in the area.

Chlamydopsis rotunda sp. nov.
(Figs 22A, 23A, 24)

MATERIAL. HOLOTYPE (QMT108593) ♀: 12.40S 142.39E Qld, 3km W Batavia Downs, 16 Sep - 24 Oct 1992, Flight Intercept Trap, P.Zborowski & T.Weir, in QMB.

DIAGNOSIS. This species and the following can be separated from the remainder of the *latipes* subgroup (see above) by the transverse basal elytral depression between the trichomes. In both of these it rises from the middle to the sides, ending, beneath the inner edges of each trichome, as a short longitudinal carina which almost meets an impunctate shelf extending inward from beneath the outer setal arc of the trichome. The lumen of the trichome is thus only visible as a short notch between these, though it is more broadly open beneath. In other species in this subgroup the basal elytral depression is

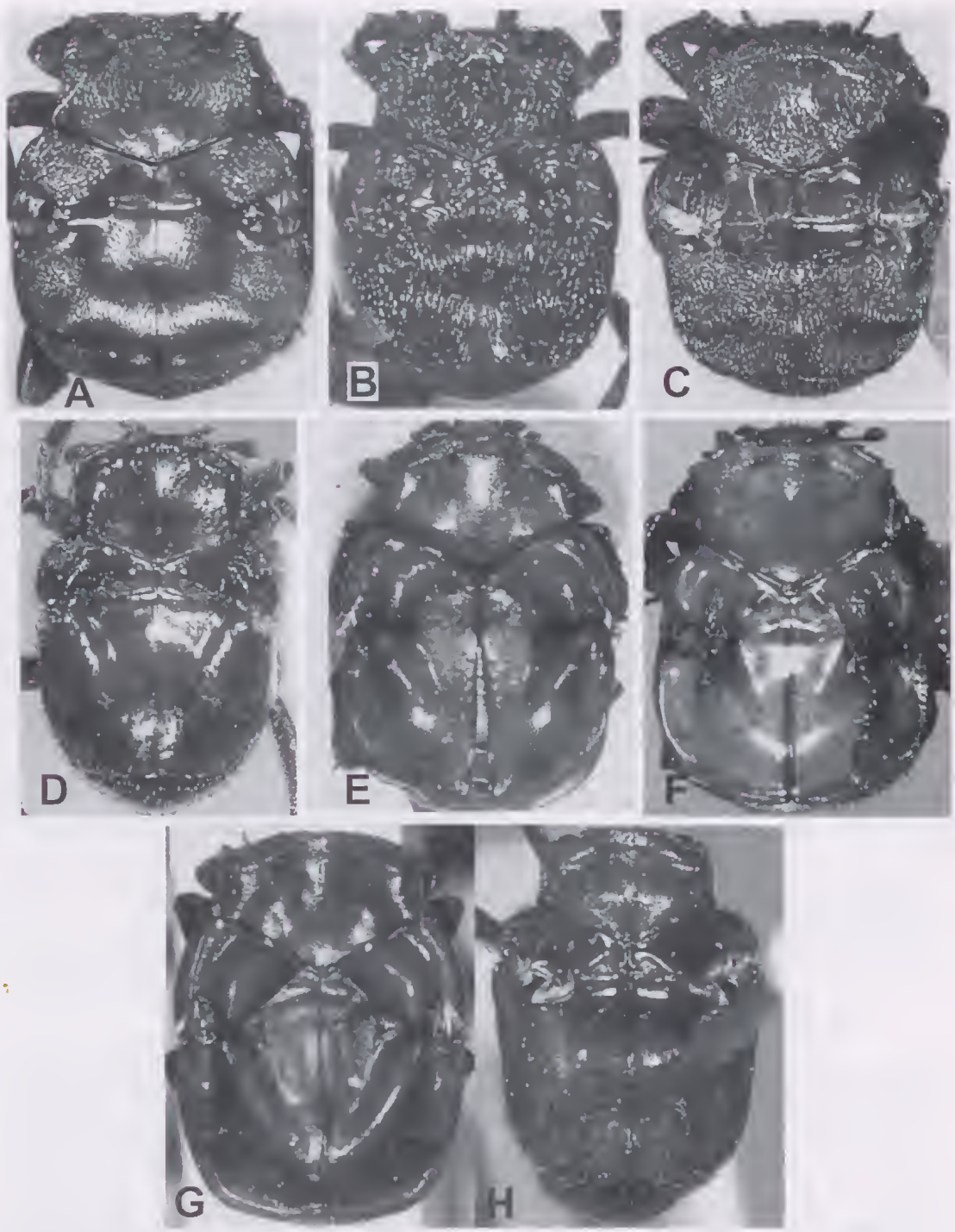

FIG. 22. Dorsal views of *Chlamydopsis* spp. A, *C. rotunda*. B, *C. latipennis*. C, *C. carinota*. D, *C. inquilina*. E, *C. detecti*. F, *C. storeyi*. G, *C. matthewsi*. H, *C. cavicollis*.

continuous with the trichome lumen, and not separated from it by a carina. The meso- and metatibiae of these two species are also not as distinctly widened as those of any of the above species. *Chlamydopsis rotunda* is distinguished from *C. latipennis* by the former's: lack of strigosity in the posteromedial half of the pronotum, more lightly strigose elytra, lack of propygidial and pygidial discal setae, and densely granulose (rather than reticulopunctate) pygidia.

DESCRIPTION. L: 3.55; W: 1.25; E/Pn L: 1.85; E/Pn W: 1.41; Pn W/L: 1.65; E L/W: 0.80; Pr/Py: 1.20; Sterna: 0.93, 0.34, 1.21; Tibiae: 1.37, 1.56, 1.84. Body dark rufescent, broadly subquadrate; sculpture varied from shallowly and finely strigose (elytra) to coarsely reticulostrigose (anterior half of pronotum); frons as wide as long, sides rounded, deeply reticulopunctate, with two prominent setae near anterior margin (number may vary in other individuals); labrum rounded, punctate; antennal scape arcuate, outer margin sinuate, widest just before middle; antennal club of female two-thirds length of scape.

Prothorax 1.6× wider than median length, sides margined, very slightly narrowed anteriorly; anterior pronotal margin elevated, the inner half of supra-antennal portions most strongly, less so at middle and at sides; pronotal disk depressed behind anterior margin, particularly strongly behind junction of median and lateral portions of margin, acutely projecting at middle and faintly convex behind middle; disk deeply reticulostrigose in anterior half, more shallowly so posteriorly, nearly smooth in much of posterior half.

Prosternum with anterior margin deeply grooved, this groove curved posteriorly and joining circumcoxal stria at sides; margin acutely projecting on either side of middle; prosternal keel narrowed posteriorly, acutely emarginate at apex; carina separating disk from protibial depressions prominent; disk densely and coarsely punctate.

Elytra 1.3× as wide as pronotum, sides parallel, approximately equally rounded to base and apex; humeral trichomes low, transversely ovoid, close to lateral margins, the opening itself limited to a short longitudinal notch, largely concealed; trichome with setose fringe around outer half of edge, this fringe nearly meeting elytral margin; inner edges of trichome elevations with small bundles of obliquely opposing setae (which do not meet in type); basal elytral depression broad, with transverse carina connecting anterior elevations of both trichomes; elytral disk undulated in posterolateral corners, coarsely strigose in anterolateral corners, much more finely strigose elsewhere; posterior margins of elytra not carinate.

Mesosternum projecting at middle, elevated along midline, anterior and lateral edges raised, otherwise depressed, coarsely punctate; meso-metasternal suture crenulately impressed; metasternum mostly smooth, very finely and sparsely punctate, with faintly alutaceous microsculpture, mesofemoral line complete to metepisternum; 1st visible abdominal sternite similar in texture to metasternum, metafemoral line ending behind coxa; legs slender, not unusually elongate; outer surfaces of all femora impunctate; protibia angulate at basal third, punctate along outer margin; meso- and metatibiae moderately broad, bluntly angulate, margins rounded, with faint setigerous punctures along outer margin, otherwise impunctate.

Propygidium 1.25× length of pygidium, shallowly depressed along anterior margin, otherwise strongly convex; pygidium flat along posterior margins, but convex at middle; both propygidium and pygidium unusually textured, rather granulately rugose, the median apical third of the pygidium slightly smoother, both with fine erect setae.

REMARKS. The name of this species refers to its rotund body shape.

Chlamydopsis latipennis Lea, 1912
(Figs 22B, 23B, 24)

Chlamydopsis latipennis Lea, 1912: 67; Lectotype, hereby designated: NW Austra/ On permanent loan from Macleay Museum University of Sydney/ *Chlamydopsis latipennis* Lea, Type, N.W. Australia, ANIC; examined, 2000.

RECORDS. ANIC: SA: Brookfield Con. Pk., 3-12.ix.1991, site 1 JL,TW&Dressler, pitfalls. This ♂ specimen is about 1.5× the size of the type, but is otherwise very similar.

DIAGNOSIS. L: 3.40; W: 1.25; E/Pn L: 1.73; E/Pn W: 1.48; Pn W/L: 1.53; E L/W: 0.77; Pr/Py: 1.28; Sterna: 0.93, 0.34, 1.12; Tibiae: 1.50, 1.62, 1.93. See diagnosis under the preceding species.

Chlamydopsis carinota sp. nov.
(Figs 22C, 23C, 24)

MATERIAL. HOLOTYPE (QMT108594) ♂: 12.40S 142.39E Qld, 3km W Batavia Downs, 16 Sep - 24 Oct 1992, Flight Intercept Trap, P. Zborowski & T. Weir.

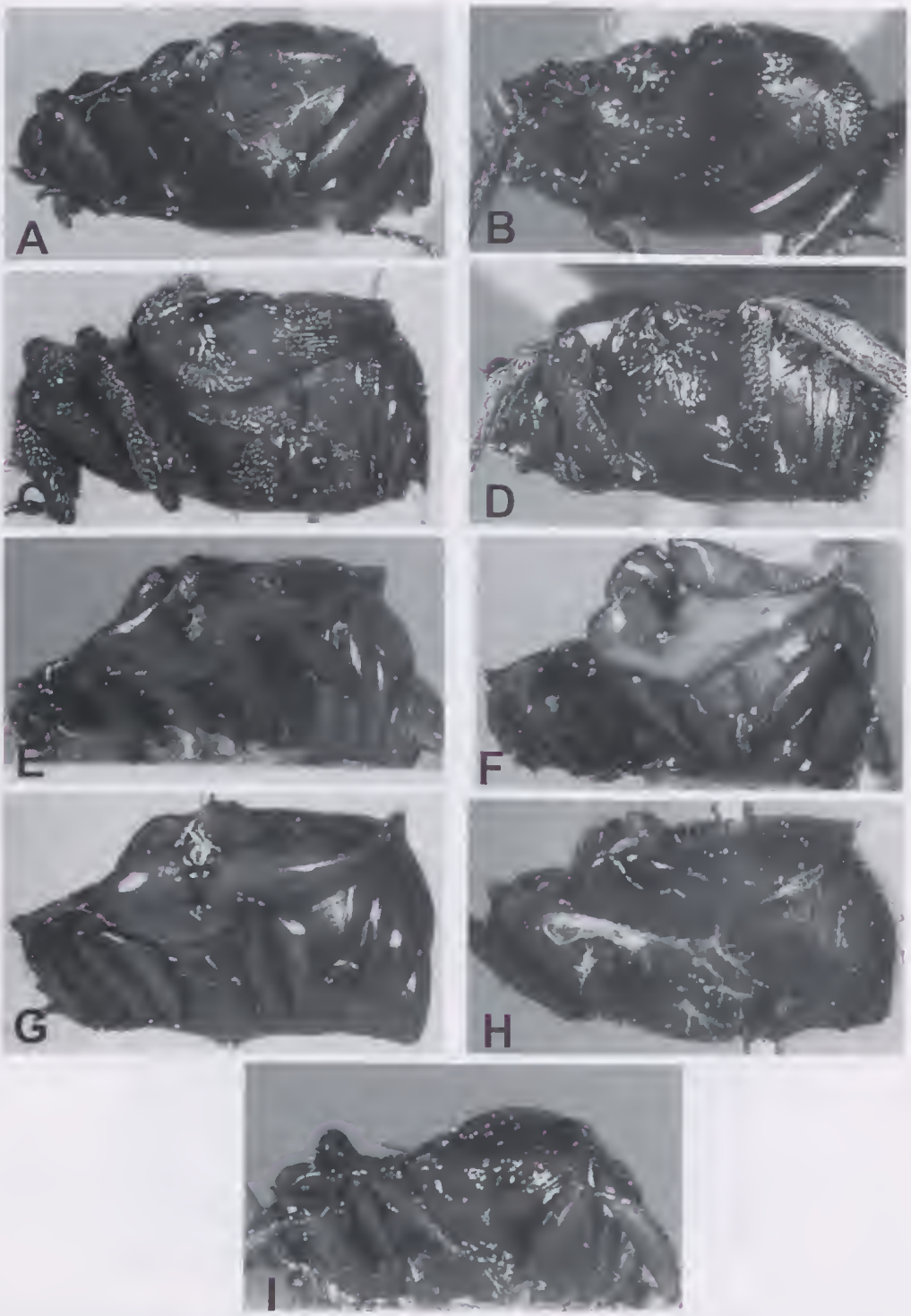

FIG. 23. Lateral views of *Chlamydopsis* spp. A, *C. rotunda*. B, *C. latipennis*. C, *C. carinota*. D, *C. inquilina*. E, *C. detecti*. F, *C. storeyi*. G, *C. matthewsi*. H, *C. cavicollis*. I, *C. tuberculata*.

DIAGNOSIS. This species is easily distinguished by the strongly upturned anterior pronotal margin, ubiquitous setae, punctatorugose metasternal disk, and prominent trichomes, which at their apices project laterally beyond the epipleuron.

DESCRIPTION. L: 2.80; W: 1.06; E/Pn L: 1.65; E/Pn W: 1.39; Pn W/L: 1.65; E L/W: 0.72; Pr/Py: 1.20; Sterna: 0.84, 0.25, 0.90; Tibiae: 1.31, 1.50, [metatibia missing]. Body light rufescent brown, all surfaces conspicuously and relatively densely setose; frons as long as wide, sides rounded, their edges slightly projecting, narrowed to base and apex; disk deeply reticulopunctate, setose; anterior frontal margin slightly rounded; labrum broad, anterior margin sinuate, projecting at middle, setose; outer bases of mandibles punctate, setose; antennal scapes arcuate, widest about one-third from base, narrowed to rounded apex, reticulopunctate and setose; antennal club of male 1.5 × length of scape.

Prothorax 1.6 × as wide as median length; sides rising from base, continuous with the strongly elevated anterior margin, the upper edges finely crenulate and setose; pronotal disk depressed behind anterior margin and at sides, convex along midline, more broadly so posteriorly, depressed mediobasally, with a small prescutellar tubercle; disk more or less evenly covered with setiferous punctures separated by about 3 × their widths, the punctures larger and less widely separated in anterior corners.

Prosternum with anterior margin strongly grooved, deflexed, sinuate, projecting on each side; marginal groove curving away from margin at sides and joining circumcoxal stria; prosternal disk depressed behind anterior margin, slightly elevated between procoxae, narrowed posteriorly, acutely emarginate at apex, densely reticulopunctate and with sparse decumbent setae.

Elytra widest at humeri, with prominent, rounded humeral trichomes; opening of trichome oval, slightly oblique, transverse, open mesally, lined with fringe of setae; superficial groove of anterior elevation close to margin, with outer edge prominent, slightly undercut, inner edge poorly defined; trichome closed laterally, with outer edge folded over, projecting laterally beyond epipleuron; basal elytral depression broad, confined to less than basal half, low transverse carinae within; posterior half unevenly convex, undulating at sides, densely reticulostrigose and setose; posterior elytral margin finely carinate, slightly elevated.

Mesosternum 3 × wider than median length, anterior margin sinuate, projecting at middle, disk more or less flat, reticulopunctate, setose; mesometasternal suture finely impressed, largely obscured by punctures; metasternal disk rather convex, densely punctate; mesofemoral line complete to, and continued on, metepisternum; 1st visible abdominal sternite entirely densely punctate, metafemoral line ending just behind metacoxa, not reaching side; legs all apparently elongate, rather slender (both metathoracic legs missing in unique type), densely punctate and clothed with long setae on outer surfaces; tibiae thickened along longitudinal axis, but abruptly thinner towards outer edge on exposed side (closely mirroring the tarsal groove on the concealed side).

Propygidium slightly longer than pygidium, depressed along basal margin but convex elsewhere.

REMARKS. The name of this species refers to its prominent, upturned anterior pronotal margin.

Chlamydopsis inquilina Lewis, 1885
(Figs 22D, 23D, 27)

Chlamydopsis inquilina Lewis, 1885: 472; ?Type: Labelled: 'Liverpool N.S. Wales (ants' nests)'. The type locality cited here is from a specimen labelled as Lewis' type in the NHM. However the original description noted only 'Australia (Duboulay)' as a type locality. Lea (1919) notes that a later citation of the type from NSW (Lea, 1912) is likely in error, and that F.H. du Boulay's specimens all originated from Western Australia. Thus it is not certain that the NHM specimen labelled as type was in fact part of the original type series.

RECORDS. NHM: WA: Swan River; WA: Mt Lawley. WAM: Cannington, in nest of *Iridomyrmex conifera*, 15.x.1952. AMS: WA: Swan River. MCZ: WA: Swan River. Lea (1919): WA: Swan River, *Iridomyrmex conifera*.

DIAGNOSIS. L: 3.05; W: 1.18; E/Pn L: 1.58; E/Pn W: 1.35; Pn W/L: 1.37; E L/W: 0.86; Pr/Py: 1.35; Sterna: 0.78, 0.25, 0.87; Tibiae: 1.46, 1.53, 1.74. Several characters distinguish this isolated species: The pronotal and elytral disks lack impressed punctures, but the conspicuously alutaceous ground texture is peppered with small, round, untextured 'pseudopunctures'; the lateral pronotal margin appears 'doubled' by an unusually prominent, carinate circumcoxal stria; the outer wall of the humeral trichome is deeply incised and lacking a dense setal fringe; the medial portions of the pronotal and elytral disks are glabrous (except on the humeral trichomes) but bear long golden setae around their margins; the dense setae of the propygidium and pygidium

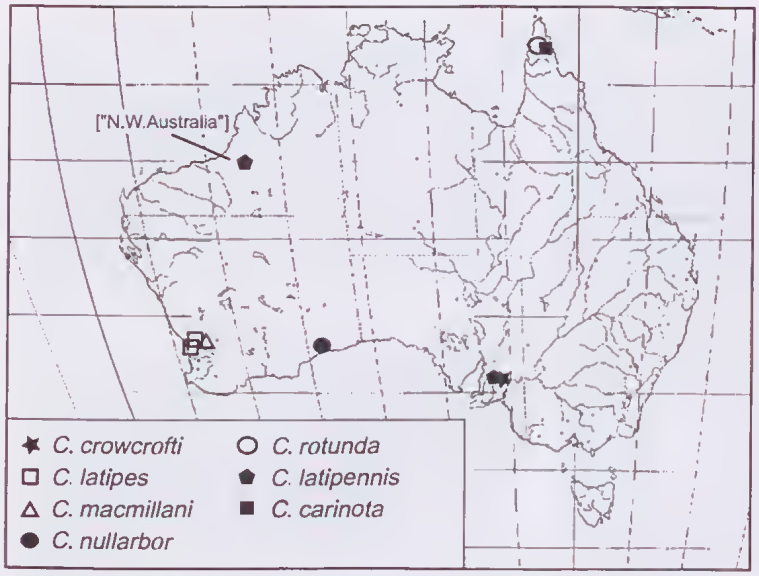

FIG. 24. Collecting records for species of *Chlamydopsis epipleuralis* group.

are much more conspicuous in this than any other species of the *epipleuralis* group.

REMARKS. Only one definite male of this species has been studied. At least that specimen was unusual among *Chlamydopsis* in lacking an elongate antennal club. It would be very interesting to determine whether this otherwise ubiquitous chlamydopsine dimorphism is truly lacking in this species. This male also possessed small dentiform metasternal processes near the posterior midline not observed in any other *Chlamydopsis*.

Chlamydopsis detecti Lea, 1914
(Figs 22E, 23E, 27)

Chlamydopsis detecti Lea, 1914b: 215; Type: *detecti* Type Lea, Dawson R./ *Chlamydopsis detecti* Lea Queensland Type, 15575; SAM, examined, 2000.

DIAGNOSIS. *Chlamydopsis detecti* and the following two new species form a distinctive and closely related group. All are larger than average for the genus, and share several characters: strongly and continuously upturned anterior and lateral pronotal margins bearing conspicuous marginal setae; carinate and elevated posterior elytral margins which continue anteriorly along the lateral margin (in *C. storeyi* sp. nov. all the way to the trichome); humeral trichomes very prominent, dominated by rather narrow, strongly elevated inner edges, which meet at a vertical mesal cleft; mediobasal elytral depression large, extending beyond middle of elytra. *Chlamydopsis matthewsi* sp. nov. is the most distinctive of these, being deep red in color and entirely glabrous dorsally (except along elytral and pronotal margins). *Chlamydopsis detecti* and *C. storeyi* are easily separated from each other by the shape of the pronotum (Fig. 22E vs 22F), which in the former is proportionally shorter, and rounded (rather than angulate) where the lateral and anterior margins meet. *Chlamydopsis storeyi* also bears prominent setae on the inner anterior elevation of the humeral trichome which are entirely lacking in *C. detecti*. However, it should be noted that *C. storeyi* is quite sexually dimorphic in surface setation and sculpture, while *C. detecti* is known from only one (undetermined) sex.

DESCRIPTION. A few additional characters of this species are noteworthy. Body rufescent, not yellow; frons granulose, without reticulate sculpture, with scattered setae; antennal scape with few setae (or small setal bundles); pronotal margins elevated, the anterior margin mostly evenly rounded but shallowly notched at middle; pronotal and elytral surfaces granulate; humeral trichomes bare on anterior surface of inner elevation; anterior and posterior inner elevations rather broad, leaning slightly toward the outside (in anterior view), arcuate around mediobasal depression; outer elevations laterally carinate, with 'V'-shaped setose incision; anterior superficial humeral groove very deeply impressed, close to lateral margin, edges bare; mediobasal depression large, with rounded, setose basal tubercles; elytra with setae along posterior half of suture; posterior elytral margin strongly carinate, the carina continuous forward along posterior one-fourth of lateral margin.

REMARKS. The type specimen was collected from a nest of '*Iridomyrmex detectus*', which has since been split into several species, three of which (*I. purpureus* (Smith), *I. sanguineus* Forel, and *I. viridaeneus* Viehmeyer) apparently occur in the range of *C. detecti*. This species is known only from the holotype.

Chlamydopsis storeyi sp. nov.
(Figs 22F, 23F, 27)

MATERIAL. HOLOTYPE (QMT108595) ♂: Australia: N WA, Kununurra, 22.XII.1991-5.I.1992, R. I. Storey, in QMB. PARATYPE ♀: same data as type.

DIAGNOSIS. See diagnosis above under *C. detecti*.

DESCRIPTION. L: 3.36; W: 1.34; E/Pn L: 1.51; E/Pn W:1.37; Pn W/L: 1.40; E L/W: 0.79; Pr/Py: 1.39; Sterna: 0.87, 0.22, 0.84; Tibiae: 1.25, 1.34, 1.37. Body light yellow-orange, with legs, trichome apices, and most major carinae darker, rufescent; most normal body striae exaggerated, carinate; female with pronotum and elytral disks largely glabrous, with setae only around margins and toward apices of trichomes; male with pronotum and elytral disks sparsely but evenly setose; frons slightly wider than long, sides rounded, narrowed gradually to apex and abruptly at base, anterior margin slightly rounded; disk convex, slightly projecting at bases of antennae, irregularly reticulopunctate and with sparse, elongate setae; labrum semicircular, with several setae; outer bases of mandibles reticulopunctate and setose; antennal scapes arcuate, widest about one-third from base, but only slightly narrowed to rounded apex, disk coarsely punctate on outer edges, but only faintly punctured, microsculptured medially; antennal club of both male and female 0.6× length of scape.

Prothorax 1.3× as wide as median length, sides margined, widening towards the front; lateral and anterior margins continuously and strongly elevated, the lateral posteriorly diminishing in height, joining posterior margin which is finely carinate; anterior margin sinuate, notched at middle, subacute on either side of notch; pronotal disk strongly depressed behind margins, convex in posterior medial half, shallowly punctate on inner surfaces of marginal elevations as well as along anterior one-third of midline, elsewhere smooth; pronotum of female glabrous except for a few setae along lateral and anterior margins, that of male with sparse but conspicuous setae on entire disk, most of them curled over, forming a loop at their apices.

Prosternum with anterior margin deflexed, very deeply grooved, the groove joining circumcoxal stria at sides; lower edge of marginal groove projecting on either side of middle; circumcoxal stria strongly carinate, these becoming doubled by keel carinae in posterior half; keel narrowed posteriorly, acutely emarginate at apex; prosternal disk sparsely punctate along anterior margin, elsewhere impunctate.

Elytra slightly wider than pronotum basally, wider towards apex; humeral trichomes very large; inner edges of anterior and posterior elevations rising vertically nearly as high as the body is deep, their opposing edges separate basally, converging, then slightly separated at apices, setose on inner margins and, less densely, on outer surfaces; outer edges of anterior and posterior trichome elevations rising only about one-third as high as inner edges, separated from them by longitudinal furrow, and at middle by nearly circular opening; outer edge of anterior superficial groove of trichome setose, prominent, forming arcuate lateral margin from basal elytral corner to trichome, inner edge of this groove well developed and setose near base, but diminishing before reaching opening of trichome; lateral margin of trichome with broad, V-shaped notch; epipleurae tuberculate and faintly punctate beneath this notch, otherwise smooth; dorsum of elytra smooth, sparsely setose in male, glabrous (except along lateral and, especially, posterior margins) in female.

Mesosternum about 4× wider than median length; margins carinate; anterior mesosternal margin projecting at middle; mesosternal disk depressed, rugose in anterior half (depression's posterior edge parallel to sinuate anterior margin), elevated and smooth in posterior half; mesometasternal suture deeply impressed; metasternum short, about 4× length of mesosternum along midline, disk smooth, with only very fine, sparse punctures; median longitudinal metasternal suture visible but not impressed; mesofemoral lines strongly carinate, complete to, and continued on, metepisternum; 1st visible abdominal sternite smooth; metafemoral lines strongly carinate, complete; legs fairly short, profemur and protibia sparsely punctate on lower surfaces, meso- and metafemora and tibiae smooth; all tibiae fairly broad, with outer margins angulate about one-third from base.

Propygidium 1.3× median length of pygidium, both nearly flat, vertical, only very slightly convex, with inconspicuous fine setae.

REMARKS. The dimorphism in setation of the pronotum and elytra in this species is unique among *Chlamydopsis*, although the preceding and the following species are closely related, and may be found to share it when both sexes of these

are known. This species is named in honor of Ross Storey, who collected and provided a substantial fraction of the material for this study.

Chlamydopsis matthewsi sp. nov.
(Figs 22G, 23G, 27, 29H, 30C)

MATERIAL. HOLOTYPE ♀: Australia N.S.W., Sturt Nat. Pk., 21km W Fortville, P.J.M.Greenslade, 22/11/79, sand dune, in SAM.

DIAGNOSIS. See diagnosis under *C. detecti*, above. This is the largest species of *Chlamydopsis* known. Its size and its deep red color are highly distinctive. The preceding species is closely related and generally similar, but in addition to the color difference, it possesses epipleural tubercles and setae near the apices of the inner upper edges of the humeral trichomes, which *C. matthewsi* lacks completely (at least in the female).

DESCRIPTION. L: 4.36; W: 1.56; E/Pn L: 1.80; E/Pn W: 1.38; Pn W/L: 1.54; E L/W: 0.85; Pr/Py: 1.47; Sterna: 1.06, 0.31, 1.03; Tibiae: 1.46, 1.62, 1.65. Body dark red, large; frons 1.4X as wide as long, sides broadly rounded, gradually narrowed to apex, abruptly narrowed at antennal bases; frons acutely projecting on each side medial to antennal insertions, shallowly depressed at sides, and elevated along anterior margin; disk sparsely punctate, slightly rugose at sides, with sparse, elongate setae; labrum rounded, glabrous; outer bases of mandibles finely punctate, glabrous; antennal scapes arcuate, widest near middle, faintly punctate, bearing scattered conspicuous setae, outer margin bluntly angulate; antennal club retracted and barely visible in type.

Prothorax 1.4× as wide as long, lateral and anterior margins strongly and continuously elevated; anterior margin somewhat uneven, shallowly notched at middle, bearing sparse fringe of curled setae; outer edge of supracoxal groove visible from above outside of dorsal lateral margin; pronotal disk strongly depressed at sides, convex along midline, slightly more prominently so posteriorly; disk finely and shallowly punctate, with a few larger punctures towards the front.

Prosternum as in the preceding species.

Elytra 1.8× as long as pronotum along midline, widest at shoulders, faintly sinuate and slightly tapering posteriorly, apical margins nearly transverse; humeral trichomes very prominent, the inner edges of anterior and posterior elevations strongly raised, almost meeting at their apices, with vertical fringes of opposing setae; lateral to these, the trichome opening is rounded, with an outer fringe of longer erect setae; lateral edge of anterior elevation delimited by the outer edge of the anterior superficial groove, which is very deeply impressed, somewhat undercut toward outside; inner edge of this groove only defined in anterior two-thirds; trichome with relatively narrow, V-shaped notch in lateral view; epipleuron lacking the suprafemoral tubercle of the preceding species; elytral disk impressed in an approximate diamond shaped area in basal two-thirds between trichomes; posterior elytral margin elevated and strongly carinate, this carina bearing setae at middle, curved anteriorly at sides but diminishing one-sixth from apex.

Mesosternum about 4× as wide as median length, anterior margin sinuate, roundly projecting at middle, grooved along anterior, lateral and posterior margins, the groove broad in anterolateral corners; mesosternal disk very finely punctate; central part of metasternum delimited on all edges by fine, continuous groove, the mesofemoral lines defining the anterolateral boundary; mesofemoral lines reaching metepisternum, but continued on it only by low, blunt ridge; median longitudinal metasternal suture complete but not strongly impressed; metasternal disk finely punctate; 1st visible abdominal sternite with fine, but deeply impressed anterior marginal groove, this groove continuous at sides with metafemoral lines, nearly reaching epipleuron; legs as in the preceding species.

Propygidium 1.3× as wide as long, 1.4× as long as pygidium along midline, both nearly vertical; propygidial disk slightly flat along basal margin, otherwise slightly convex, finely punctate and faintly rugose in basal half; pygidium slightly concave at sides, finely punctate, and slightly rugose throughout.

REMARKS. This species is named in honor of Eric Matthews, who has provided valuable material and information throughout the course of this study.

Chlamydopsis cavicollis Lea, 1912
(Figs 22H, 23H, 27)

Chlamydopsis cavicollis Lea, 1912: 65; Lectotype, hereby designated: Sydney [NSW]/ On permanent loan from Macleay Museum University of Sydney/ *Chlamydopsis cavicollis* Lea, N.S.Wales; ANIC, seen, 2000.

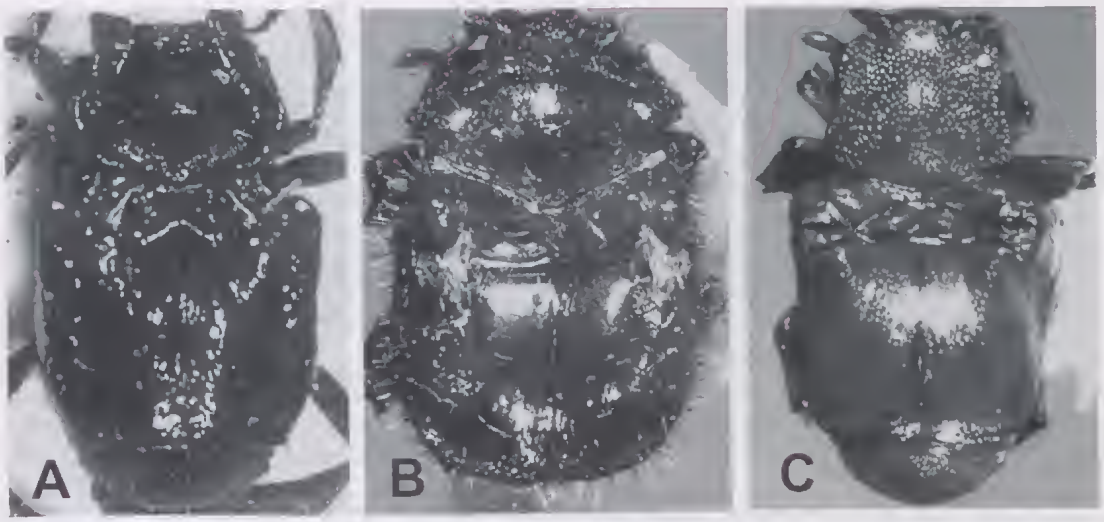

FIG. 25. Dorsal views of *Chlamydopsis* spp. A, *C. tuberculata*. B, *C. mareeba*. C, *C. parallelus*.

DIAGNOSIS. While its continuous, elevated lateral and anterior pronotal margins ally it with the preceding three species, this species is very distinctive. The body shape (Fig. 22H) is unusual, with the pronotum very small relative to the elytra, and the elytra narrowing from the humeri to the apex. The epipleural cleft of the trichome is unique, forming a long, narrow, posteriorly curving incision. Additional unusual characters include: anterior and lateral pronotal margins lined with prominent setal bundles; anterior and posterior elevations of humeral trichomes each with two separate bundles of setae; posteromedial elevation of trichome only weakly elevated; inner edge of anterior humeral groove not well developed, the outer prominent, scooplike; marginal epipleural carina not arcuate over metathoracic leg; legs elongate and very slender; elytral dorsum and pygidia with numerous discal setae.

REMARKS. This species is known only from the holotype, which has suffered some dermestid damage, and is missing most of its legs.

INCERTAE SEDIS

The following three species are not obviously related to any of the preceding species groups and are left unaffiliated.

Chlamydopsis tuberculata Lea, 1912
(Figs 23I, 25A, 27)

Chlamydopsis tuberculata Lea, 1912: 54; Type (♀): *tuberculata* Lea Type, Ballarat/ 14670, *Chlamydopsis tuberculata* Lea, Victoria, mounted with separate card, originally with two host individuals, only part of one individual remaining; SAM; seen 2000.

MATERIAL. MCZ: Vic: Lorne, x.1918. Lea (1919): Vic: Lorne, 'with a small black species of *Iridomyrmex*'. Oke (1923): Vic: Grampians; Vic: Macedon.

DIAGNOSIS. *Chlamydopsis tuberculata* is easily separated from all other *Chlamydopsis* by the pronotum. It not only bears a prominent, blunt, transverse tubercle, but is more strongly and continuously elevated along anterior and lateral margins than any other species. The shape of the pronotum, widening posteriorly (in dorsal view), is also distinctive. Additional distinguishing characters include the position of the humeral trichomes, situated very close to the anterolateral elytral corners, the very shallow, indistinct reticulation of the elytra, and the rather slender but marginally rounded tibiae.

REMARKS. With regards to this species' phylogenetic affiinities, one of the more significant characters is the lack of marginal prosternal groove (plesiomorphy), which excludes it from the *epipleuralis* and *ectatommae* groups. There is some similarity in trichome with species in the *striatipennis* group. However, subtle differences have prevented the recognition of these as potential synapomorphies. No genitalia have been examined due to the rarity of specimens. The ovipositor will likely reveal additional clues as to the relationships of the species.

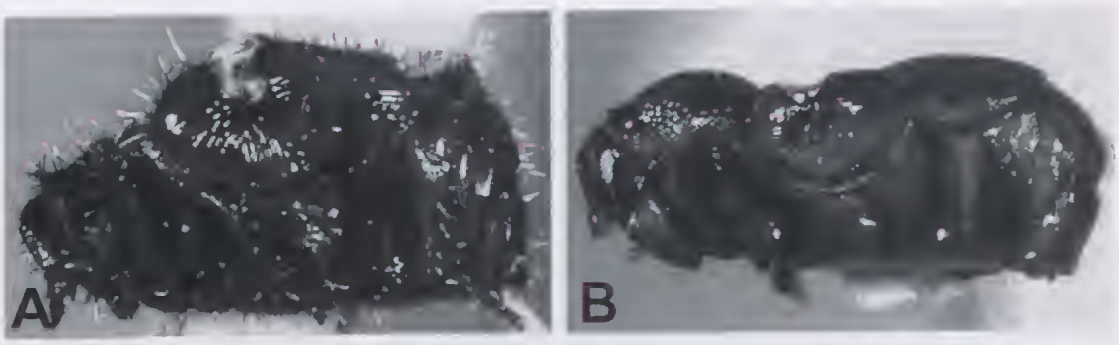

FIG. 26. Lateral views of *Chlamydopsis* spp. A, *C. mareeba*. B, *C. parallelus*.

Chlamydopsis mareeba sp. nov.
(Figs 25B, 26A, 27)

MATERIAL. HOLOTYPE (QMT108596) ♀: 6km SE of Mareeba, Qld., 16.xii-20.i.1991, S.DeFaveri, F.I.T. site 36.

DIAGNOSIS. This species, although difficult to place phylogenetically, is very distinctive. The combination of prosternal marginal groove, deeply transversely incised humeral trichome bearing near continuous setal fringe, and impunctate, plurisetose elytra are sufficient to separate it from other known species. It should be noted, however, that the unknown male may not conform to this diagnosis.

DESCRIPTION. L: 2.55; W: 0.93; E/Pn L: 1.73; E/Pn W: 1.18; Pn W/L: 1.63; E L/W: 0.90; Pr/Py: 1.16; Sterna: 0.65, 0.19, 0.69; Tibiae: 0.87, 1.00, 1.03. Body rufescent, quadrate, dorsal surface mostly impuneate, with numerous elongate setal bundles; frons about as long as wide, sides rounded, disk uniformly convex, with broad shallow punctures slightly separated by faintly microseulptured areas, with a couple small setal bundles; labrum rounded, weakly punetate, glabrous; antennal scape bluntly angulate near its outer midpoint, abruptly narrowed to base, more gradually to apex; surface of seape with clongate, shallowly impressed punetures, a few setal bundles; antennal club of female about two-thirds length of seape.

Pronotum 1.5× as wide as median length; sides margined, widened and slightly clevated towards front; anterior margin elevated, median and lateral portions continuous, and continuous with lateral margins; disk depressed behind anterior margin, eonvex posteriorly, nearly smooth at middle, very faintly reticulopunctate at sides and front; anterior and lateral margins, and to a lesser extent the disk with eonspieuous punetures bearing bundles of elongate setae.

Prosternum with anterior margin deeply grooved, sinuate and acutely projeeting on either side, marginal groove eurving posteriorly at sides and merging with circumcoxal stria; prosternal keel narrowed posteriorly, widening slightly behind proeoxae, apex bluntly emarginae, with

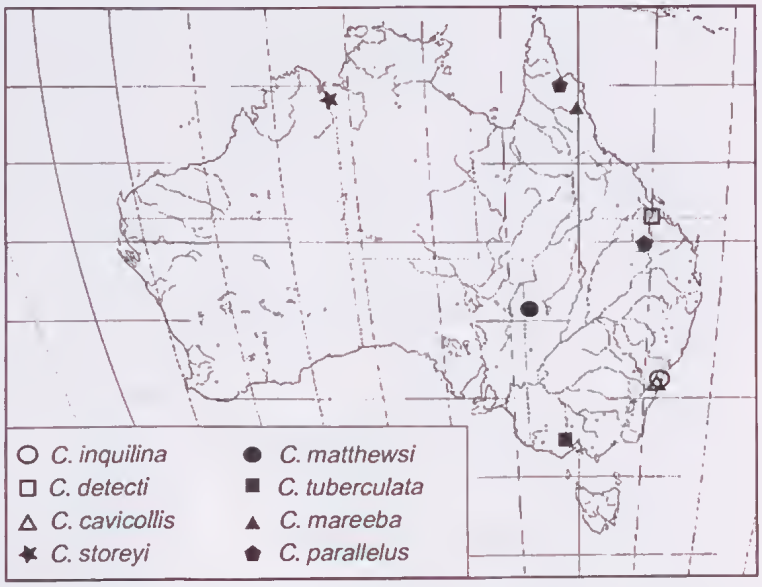

FIG. 27. Collecting records for species of *Chlamydopsis epipleuralis* group and unplaced species.

deeply impressed marginal stria along edges of leg depressions and posterior margin of keel; prosternal disk with shallow punctures separated by about their widths, faintly alutaceous between, with sparse, irregularly scattered bundles of setae.

Elytra together about 1.2 × as wide as base of pronotum, more or less parallel-sided, narrowed more gradually to apex than to base; humeri strongly, narrowly elevated, the posterior elevation extending back about two-thirds from the elytral base; elevations deeply incised transversely by trichome opening, setal fringe consisting of anteriorly and posteriorly directed tufts from inner edges of opening, these barely discontinuous with outer fringe, which extends from apices of elevations continuously around lateral incision; apices of anterior and posterior elevations both emarginate above opening, with the setal fringe following emargination; anterior elevation strongly convex, its anterior surface nearly vertical, anterior superficial groove rather shallowly impressed, extending from humeral corner slightly inwardly to apical emargination of anterior elevation; mediobasal depression large, with transverse carinae, from suture arching posteriorly to beneath trichome; dorsal portion of elytral disk almost entirely impunctate, with only faint punctures posteriorly, with numerous elongate setae, most in bundles of 2-4 setae; epipleuron strigose, with strigae converging to trichome opening.

Mesosternum about 4 × as wide as median length; slightly elevated along midline, depressed at anterior corners; texture like that of prosternum; mesometasternal suture deeply impressed, continuous with postmesocoxal groove; longitudinal metasternal stria not impressed, barely detectable; metsternal disk with alutaceous microsculpture, with sparse, deep setigerous punctures, otherwise impunctate; 1st abdominal sternite with denser, but smaller, punctures than metasternum, most setae single; legs short, slender with sparse, elongate punctures interspersed with smaller setigerous ones, most setae in bundles; pro- and mesotibiae acutely angulate near basal one-third, metatibia more rounded.

Propygidium convex, with slightly elongate punctures separated by about their widths interspersed with sparser deeper punctures bearing bundles of setae; pygidium similarly textured in basal half, punctures fewer in apical half.

REMARKS. Although superficially similar to the females of *C. monteithi* and *C. setifera* in the *strigicollis* group above, the vertical superficial humeral groove and deeply grooved anterior prosternal margin of this species argue against a close relationship. Discovery of the male would be very helpful in placing it. Its name refers to the Queensland town close to the type locality.

Chlamydopsis parallelus sp. nov.
(Figs 25C, 26B, 27)

MATERIAL. HOLOTYPE (QMT108597): 15.11S 143.52E Hann River Qld 15 Sep - 20 Oct 1993 Flight Intercept Trap P.Zborowski & D.Rentz. PARATYPE ♀: SEQ: 25°13'S 149°01'E, Expedition Ra. Nat. Pk., 5729 Amphitheatre yards, 440m 19.xii.97-4.iii.1998, DC&GM, open for. FIT.

DIAGNOSIS. The elongate body form is very distinctive. Its body length is slightly over twice its width across the humeri, and the median pronotal length is just about equal to its basal width. In characters of phylogenetic significance, however, the species is not particularly remarkable. The anterior marginal prosternal groove is well developed, diverging to meet the circumcoxal stria at the sides. The humeral trichomes are moderately well developed, with laterally discontinuous, otherwise nearly circular setal fringe. The carinae of the mediobasal depression are unusual, forming laminate transverse peaks, rising steeply from along the elytral suture behind the scutellum, but extending only about two-thirds of the way to the humeral trichome.

DESCRIPTION. L: 1.84; W: .065; E/Pn L: 1.81; E/Pn W: 1.25; Pn W/L: 1.14; E L/W: 1.27; Pr/Py: 1.36; Sterna: 0.50, 0.12, 0.44; Tibiae: 0.47, 0.50, 0.53. Body narrow, elongate, light rufescent brown; frons about as wide as long, weakly convex, sides rounded, disk shallowly punctate, the punctures larger and more conspicuous nearer the anterior frontal margin, appearing granulate within each puncture; anterior frontal margin slightly outwardly arcuate, labrum rounded, with a few small punctures; outer margin of antennal scape bluntly angulate just basad of midpoint, abruptly narrowed basally, more gradually to apex, surface microsculptured but impunctate, very finely setose; antennal club of female two-thirds length of scape, sclerotised over much of its surface, with only a couple small tomentose patches on outer surface near apex.

Pronotal median length equal to basal width, sides unmargined, inwardly arcuate, similar in width basally and apically, narrowest about one-third from front; anterior margin weakly elevated, very shallowly emarginate across

middle, more deeply so above antennal cavities; disk depressed in anterior corners, strongly convex along midline, somewhat transversely elevated in posterolateral corners; disk shallowly, but more or less evenly punctate, the punctures toward the sides slightly elongated.

Prosternum with anterior margin deeply grooved, sinuate and acutely projecting on either side, marginal groove curving posteriorly at sides and merging with circumcoxal stria; prosternal keel narrowed posteriorly, widening slightly behind procoxae, apex weakly emarginate, with fine marginal stria; prosternal disk with shallow punctures separated by slightly less than their widths, with very fine interspersed setae.

Elytra 1.2× as wide as pronotum, with sides approximately parallel, though slightly sinuate at middle; humeral trichomes moderately elevated, close to humeral corners, trichome broadly open dorsally, nearly circular, slightly wider than long, fringed with short, dense setae which do not completely obscure the opening, this fringe briefly interrupted at sides, and, weakly, at the junction with the anterior superficial humeral groove; humeral groove well impressed, its edges rounded, extending from humeri to inner apex of trichome; mediobasal elytral depression confined to basal one-third, with prominent, slightly oblique transverse basal carinae, these bluntly triangular, laminate; elytral disk evenly convex in apical half, apical margin not carinate; disk shallowly and sparsely strigose, with scattered fine setae.

Mesosternum about 3× as wide as median length, anteriorly weakly projecting, with faintly impressed lateral and anterior marginal stria, disk with large shallow punctures, and smaller ones interspersed; mesometasternal stria shallowly impressed; longitudinal metasternal suture very fine, barely visible; metasternal disk finely and sparsely punctate, with scattered minute setae; 1st abdominal sternite similarly textured to metasternum. Legs short, broad; meso- and metatibiae nearly half as wide as long; protibia bluntly angulate just beyond basal one-third; outer margins of posterior tibiae, only faintly angulate, very nearly rounded; all legs impunctate, with fine setae; tarsi laterally compressed.

Propygidium strongly convex, faintly alutaceous, with sparse, shallow punctures, fine setae; pygidium weakly convex, faintly alutaceous, with weak punctures only in basal one-third.

REMARKS. One specimen from Western Australia '14.26S, 126.38E, CALM Site 13/4 12km S of Kalumburu Mission' [ANIC] is closely related to this species, and possibly the same. However, its body is broader and less elongate. Given the geographic distance, it seems likely that this difference will be bridged by intervening forms. Its status will need to reassessed when additional material can be studied. The name of this species refers to its elongate, nearly parallel-sided body form.

SUMMARY OF KNOWN SPECIES AND SPECIES GROUPS OF *CHLAMYDOPSIS*

striatipennis group
1. *C. striatipennis* Lea
2. *C. leai* Oke
3. *C. compressipes* Lea
4. *C. pallida* Lea
5. *C. rana* sp. nov.
6. *C. antennata* sp. nov.
7. *C. trichonota* sp. nov.

strigicollis group
8. *C. reticulata* Lea
9. *C. dimorpha* sp. nov.
10. *C. strigicollis* Oke
11. *C. mormolyce* Lea
12. *C. monteithi* sp. nov.
13. *C. setifera* sp. nov.
14. *C. lawrencei* sp. nov.

pygidialis group
15. *C. pygidialis* Blackburn
16. *C. carinicollis* Lea
17. *C. serricollis* Lea
18. *C. setipennis* Oke
19. *C. convergens* sp. nov.
20. *C. coronis* sp. nov.
21. *C. erupta* sp. nov.
22. *C. transversa* sp. nov.

longipes group
23. *C. longipes* Lea
24. *C. inaequalis* Blackburn
25. *C. agilis* Lea

ectatommae group
26. *C. ectatommae* Lea
27. *C. kununurra* sp. nov.
28. *C. acutricha* sp. nov.
29. *C. myrmecophila* sp. nov.
30. *C. variolosa* Lea
31. *C. mallee* sp. nov.
32. *C. pecki* sp. nov.
33. *C. loculosa* Lea
34. *C. degallieri* sp. nov.
35. *C. papuae Lewis*
36. *C. jayawijaya* sp. nov.
37. *C. lucifer* sp. nov.
38. *C. bataviae* sp. nov.

39. *C. burnetta* sp. nov.
40. *C. zborowskii* sp. nov.
41. *C. pluriseta* sp. nov.
42. *C. contorta* sp. nov.
43. *C. pilosipes* sp. nov.
44. *C. bifovaecollis* (Oke)
45. *C. nielseni* sp. nov.
46. *C. australis* sp. nov.
47. *C. lepida* sp. nov.

epipleuralis group

48. *C. epipleuralis* Lea
49. *C. sculptus* Oke
50. *C. convexa* sp. nov.
51. *C. striatella* Westwood
52. *C. formicicola* (King)
53. *C. dispersa* sp. nov.
54. *C. weiri* sp. nov.
55. *C. crowcrofti* sp. nov.
56. *C. latipes* Lea
57. *C. macmillani* sp. nov.
58. *C. nullarbor* sp. nov.
59. *C. rotunda* sp. nov.
60. *C. latipennis* Lea
61. *C. carinota* sp. nov.
62. *C. inquilina Lewis*
63. *C. detecti* Lea
64. *C. storeyi* sp. nov.
65. *C. matthewsi* sp. nov.
66. *C. cavicollis* Lea

incertae sedis

67. *C. tuberculata* Lea
68. *C. mareeba* sp. nov.
69. *C. parallelus* sp. nov.

PHYLOGENY

This analysis is based on external morphological variation as well as some characters of the ovipositor. While some variation in male genitalia has been observed (primarily in setal patterns and apical curvature), insufficient dissectable males were available to include any male characters in this study. The matrix of female genitalic characters does contain substantial missing data, but the states were much more distinctive and obviously informative. This analysis includes all known species of *Chlamydopsis*, including one recently discovered New Caledonian species, to be formally described elsewhere. The outgroups represent a broad selection of other Chlamydopsinae, as well as three non-chlamydopsine histerids. These are: *Stictostix frontalis* Lea (Tribalinae), a new Malaysian genus near *Peploglyptus* (Onthophilinae; description in preparation), *Onthophilus flohri* Lewis (Onthophilinae) and the chlamydopsines *Pheidoliphila minuta* Lea, *Orectoscelis dumogae* Caterino, *Orectoscelis obliquus* Caterino, *Ceratohister* sp., *Eucurtia comata* (Blackburn), *Ectatommiphila opaca* (Lea), representatives of two undescribed genera close to *Orectoscelis*, and a representative of one undescribed genus of obscure affinities. The complete data set contains 82 taxa and 46 characters.

CHARACTERS.

1. Frons: *1.* without prominent tubercles; *2.* with single broad protuberance; *3.* with multiple (usually 6) protuberances.
2. Labrum, apical margin: *1.* evenly rounded, nearly semicircular; *2.* broader, nearly straight for some distance at middle.
3. Antennal insertion: *1.* at the middle of the frons; *2.* at the top of the frons near the top of the eye. This character is generally considered the defining synapomorphy of Chlamydopsinae.
4. Antennal club: *1.* identical in length in both sexes, generally less than twice as long as wide; *2.* more elongate in ♂, usually three or more times as long as wide. The strongly dimorphic antennal club, with that of the ♂ extremely elongated, is nearly ubiquitous in Chlamydopsinae. However, in one species, a ♂ with a short antennal club has been seen. The small number of specimens examined leaves some doubt that this represents more than an aberration.
5. Medial portion of anterior pronotal margin: *1.* flat, neither thickened nor elevated; *2.* distinctly elevated, with some anteriorly exposed surface below margin.
6. Anterior pronotal margin: *1.* median transverse and lateral oblique portions continuous; *2.* interrupted between median and lateral portions, either by notch or by a carina. State two encompasses considerable diversity that could perhaps be more finely divided. In some of these species the median segment of the anterior pronotal margin (that portion above the vertex of the head) is elevated separately from the lateral portions (those above the antennal cavities). In others the median and lateral portions meet, but the inner apex of the lateral portion extends for a very short distance anteriorly beyond the median portion. Grouping these conditions together as a state suggests that the origin of discontinuity, in whatever form, was the significant change, with diversity arising after.
7. Pronotum: *1.* without a stria behind elevated lateral portion of anterior margin; *2.* with an oblique stria extending along posterior base of lateral portion of (usually) elevated anterior margin. This stria, when present, extends from the lateral pronotal margin, behind lateral portion of anterior margin, to the anterior margin between its lateral and median portions.
8. Anterior pronotal margin, median portion: *1.* even at middle, whether elevated or not; *2.* notched at middle.
9. Pronotum: *1.* pronotum margined laterally; *2.* pronotum without lateral margin.
10. Pronotum: *1.* lateral margins flat, not elevated; *2.* lateral margins elevated, angulately continuous with lateral portions of anterior margin; 3. lateral and anterior margins indistinguishable, forming a single oblique carina from anterior midpoint to each posterolateral pronotal corners. State three applies only to single unusual species from New Guinea (new genus3). The relationships of this species are unclear but it appears to be outside of *Chlamydopsis*.

11. Pronotal trichomes: *1.* absent; *2.* present (Figs 1E-G). Pronotal trichomes occur in only a few *Chlamydopsis*, and, although somewhat similar, they are not identical in form in those species possessing them. Nonetheless, due to their rarity, they are considered potentially homologous where they occur.

12. Anterior marginal or near marginal processes of pronotal disk: *1.* absent; *2.* present as two distinct swellings (or single bifid process) at or near anterior margin. This character as scored mainly separates *Chlamydopsis* from chlamydopsine outgroups, most of which possess some form of paired marginal pronotal processes.

13. Single median pronotal tubercle: *1.* absent; *2.* present. This character had previously been combined with the preceding character. However, although not observed it appears possible for anterior marginal and median processes to co-occur.

14. Median pronotal tubercle: *1.* absent; *2.* simple; *3.* expanded laterally to form transverse carina. This character is dependent on the presence of a pronotal tubercle in the preceding character.

15. Pronotum: *1.* without longitudinal carina; *2.* with longitudinal carina along midline in anterior half (sometimes also with posterolateral extensions).

16. Anterolateral groove from antennal cavity to pronotum; *1.* absent; *2.* present, simple, merging with prosternal circumcoxal stria at side (Fig. 28D). *3.* present and leading to dorsal pronotal pit (Fig. 29A). State 2 indicates a groove running from the upper edge of the antennal cavity upward, intersecting the lateral portion of the anterior pronotal margin, thence extending posterolaterally to the lateral pronotal margin below which it meets the circumcoxal stria. The groove exhibited in state 3 is potentially homologous with this one (although this is not asserted by the present coding scheme). However, in those taxa exhibiting state 3 the groove extends straight back from the antennal cavity and terminates in conspicuous dorsal pronotal pits. This state is diagnostic of the *bifovaecollis* subgroup of the *ectatommae* group.

17. Prosternal disk: *1.* length anterior to profemoral carina less than that posterior to carina; *2.* length anterior to carina equal to or greater than length posterior to carina. State 2 is characteristic of a large section of non-*Chlamydopsis* chlamydopsines.

18. Anterior marginal stria of prosternal lobe: *1.* not deeply grooved (Fig. 28A); *2.* deeply grooved, the groove running along margin all the way to side, not continuous with the circumcoxal stria (Fig. 28B); *3.* deeply grooved, departing from margin at sides and curving posteriorly to meet the circumcoxal stria (Fig. 28C). This character has proven one of the most useful for sorting out preliminary affinities within *Chlamydopsis*. These grooves would appear to constitute some kind of conduit system on the beetles' surface. In several species these grooves meet elytral grooves to form a continuous series extending all the way to the humeral elytral trichomes. Perhaps these serve to disperse recognition substances from a site of origin to elsewhere on the body.

19. Prosternal disk: *1.* without transverse stria behind anterior margin; *2.* Prosternum with transverse stria just behind anterior margin. This stria, when present, is reminiscent of the 'presternal stria' of many non-chlamydopsine Histeridae, and may conceivably be homologous, it being present in a couple of the outgroups.

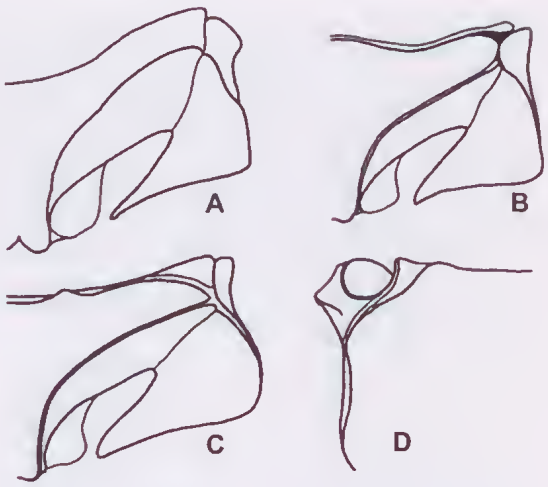

FIG. 28. A-C, Ventral view of left half of prosternum of *Chlamydopsis* spp. A, *C. striatipennis*. B, *C. monteithi*. C, *C. burnetta*. D, Dorsal view of left half of pronotum of *C. kununurra*, showing anterolateral groove.

20. Scutellum: *1.* visible dorsally; *2.* hidden. This character is informative only with respect to outgroups.

21. Humeral elytral trichome: *1.* absent; *2.* present. This and the following several characters refer to the structure of the humeral trichome, or 'epaulette' of most previous authors. This structure is extremely varied, and unquestionably informative at some levels. However, it is very difficult to determine homologies among the various components. Some of the characters below are admittedly interdependent, and other scoring schemes could be justified, but no wholly satisfactory schemes have yet been found.

22. Position of humeral trichome: *1.* absent; *2.* behind humeri; *3.* limited to humeri; *4.* trichome largely posthumeral, but extending forward mesally to anterior elytral margin or even to humerus. The position of the trichome is primarily informative with respect to non-*Chlamydopsis* outgroups. However, in a few *Chlamydopsis* the degree to which the trichome extends forward toward the anterior elytral margin may be informative.

23. Anterior superficial groove of trichome: *1.* with anterior groove up the middle of the anterior elevation, approximately evenly dividing it into inner and outer prominences (Figs 29A-B, E-G); *2.* with anterior groove oblique or horizontal, entering the lumen of the trichome at its mesal base (Figs 29C-D); *3.* without any visible groove on anterior elevation of trichome (Fig. 29I); *4.* with anterior groove displaced laterally, forming a lateral margin of the anterior elytral corner (Fig. 29H). This groove, nearly always present in *Chlamydopsis*, is quite varied in form. Its absence in a few species is almost certainly due to loss, as in most cases it can be seen in apparent relatives. The orientation of this groove, when present, varies considerably. It may appear almost perfectly longitudinal, forming a marginal groove and entering the trichome laterally (e.g. *C. detecti* and relatives). Or it may take the opposite extreme, being directed strongly medially, in some cases

lying nearly parallel to the anterior elytral margin (e.g. *C. mormolyce* and other members of the *strigicollis* and *pygidialis* groups), entering the opening of the trichome from its inner side. These changes of position may be viewed as the results of differential development on either side of a (putatively) symmetric plesiomorphic state (state 1).

24. Setal fringe of humeral trichome: *1.* as a single continuous marginal fringe, usually encircling fairly simple trichome opening (e.g. *C. bifovaecollis*; Figs 29A-C); *2.* with anterior marginal and posterior marginal fringes, discontinuous laterally and mesally (Figs 29D-E); *3.* with three distinct origins, semicircular fringe along outer edge separated from anterior and posterior inner bunches of setae (Fig. 29F-H); *4.* trichome setae arising from two origins, one in an elongate (usually sinuate) fringe along the inner edge of the dorsal 'roof' of the trichome, and one within the small mesal opening of the trichome, mostly hidden by the dorsal fringe (Fig. 29I; inner fringe not visible in figure); **5.** with a single small setal origin on the mesal surface of incurved anterolateral trichome elevation (e.g. *C. pallida*); **6.** trichome absent, character inapplicable. Although this character focuses on the origin points of the trichome setae, it in fact captures much of the variation in overall shape of the trichome itself.

25. Inner edges of anterior and posterior trichome elevations: *1.* well developed but not meeting, the lumen of the trichome open to mediobasal depression (Figs 29A-D, I) ; *2.* well developed and nearly or fully meeting, closing trichome mesally (full closure may be achieved by setal fringes on their opposing surfaces; Figs 29E-H); *3.* inner edges joined by a thin lamina, closing trichome mesally (e.g. *C. pallida*); *4.* trichome unelevated or absent, character inapplicable.

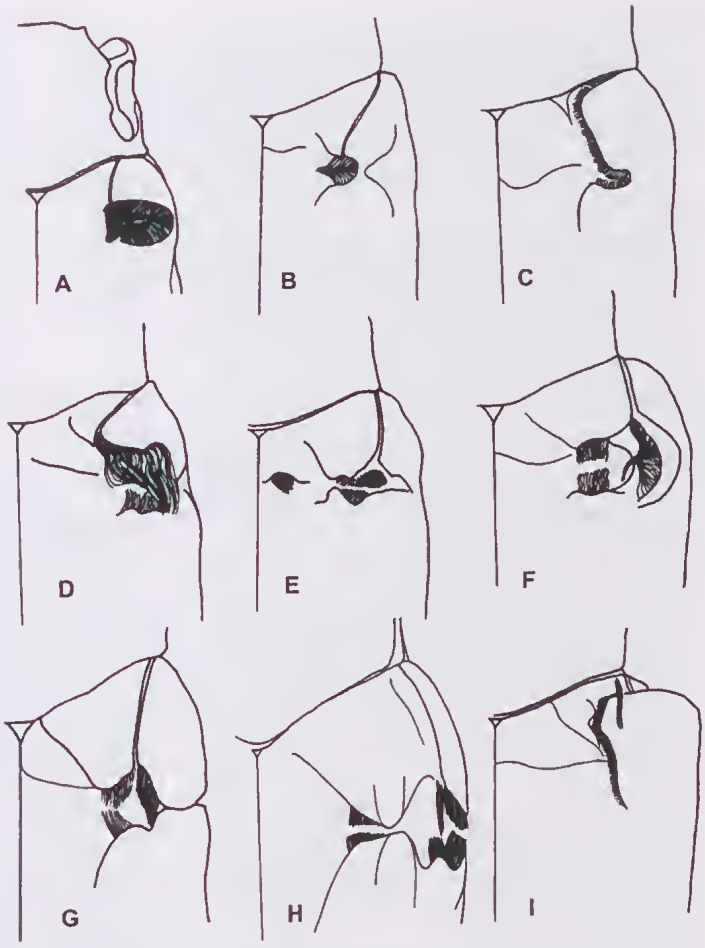

FIG. 29. Humeral trichomes of right elytron of *Chlamydopsis* spp. A, *C. bifovaecollis*, also showing pronotal pit. B, *C. myrmecophila*. C, *C. inaequalis*. D, *C. reticulata*. E, *C. burnetta*. F, *C. nullarbor*. G, *C. dispersa*. H, *C. matthewsi*. I, *C.* sp. nr. *striatipennis*.

26. Outer edges of anterior and posterior trichome elevations: *1.* not closing the trichome laterally; *2.* meeting, closing trichome laterally (a notch may be present as long as it is not continuous with trichome lumen as in, e.g. *C. myrmecophila*); *3.* trichome unelevated or absent, character inapplicable. Sexual dimorphism is responsible for the one scored polymorphism in this character (in *C. mallee*). Other species, once both sexes are discovered, may need to be rescored for this character.

27. Trichome lumen: *1.* lumen (central cavity) broadly open dorsally; *2.* lumen covered dorsally, with only a small mesal opening leading to internal cavity (detectable via a 'window' of thin cuticle on trichome's lateral surface; see, e.g. *C. striatipennis*; Figs 29C, I); *3.* trichome absent, character inapplicable.

28. Carinae of midbasal elytral depression: *1.* absent, depression flat (or not depressed); *2.* with transverse (in some slightly arcuate) transverse carinae.

29. Carinae of midbasal elytral depression: *1.* absent; *2.* bare or sparsely setose; *3.* bearing dense bundles of setae (Fig. 29E). This character refers to a specialisation of the preceding.

30. Elytral marginal stria: *1.* continuous along elytral suture; *2.* absent at least along suture.

31. Elytron: *1.* apical margin flat; *2.* with apical marginal carina (which is separate from marginal stria); *3.* with apical marginal carina extending forward along lateral edge to humeral trichome.

32. Elytra of ♂ and ♀: *1.* identical in surface texture; *2.* differing substantially in texture such that females are smooth and males are reticulostrigose.

33. Prosternal/mesosternal junction: *1.* mesosternum projecting, prosternum emarginate; *2.* prosternum posteriorly truncate to rounded, projecting over anterior margin of mesosternum.

34. Meso- and metatibiae: *1.* without grooves for retraction of tarsi; *2.* with grooves for retraction of tarsi. This character is only informative with respect to outgroups.

35. Ventral cavities for retraction of legs: *1.* poorly developed, not margined all the way around; *2.* well developed, completely delimited by carinae (femoral lines). This character is related to character 38, below, in that elongate legs tend to be accompanied by loss of well-defined cavities.

36. Mesofemur: *1.* not clavate, less than twice as thick at apex as at base; *2.* clavate, twice as thick or more at apex than base. This and the following character, as defined, pertain mainly to the *longipes* group, although there is a tendency towards the femora becoming clavate with increasing length throughout the group.

37. Metafemur: *1.* not clavate, less than twice as thick at apex as at base; *2.* clavate, twice as thick or more at apex than base.

38. Metatibia: *1.* short, slender, outer margin angulate; *2.* short, broad, outer margin angulate; *3.* short, broad, outer margin rounded; *4.* elongate (in practical terms, extending above epipleuron when held vertically); *5.* short, slender, outer margins even.

39. Metatibia, if elongate: *1.* not elongate; *2.* broad, angulate; *3.* broad, rounded; *4.* slender

40. Tarsal claws: *1.* evenly curving to apex (particularly note inner edge); *2.* inner edge straight for approximately basal two-thirds, then curved just at apex; *3.* short, nearly perpendicularly bent at base, then straight in apical two-thirds; *4.* long, thin, nearly straight througout.

41. Propygidium: *1.* flat to convex, at least in ♂; *2.* with transverse carina or series of protuberances in both sexes.

42. Body setae: *1.* simple; *2.* scale-like; *3.* absent; *4.* simple, in bundles. There is considerably more variation in setal types in chlamydopsine outgroups. Within *Chlamydopsis* this character is mainly informative with respect to whether the simple setae are borne singly or in 'bundles' of multiple setae.

43. Gonocoxite of ovipositor: *1.* less than half as long as valvifer (Figs 30A, C); *2.* coxite half or more as long as valvifer (Fig. 30B).

44. Gonocoxite of ovipositor: *1.* apex bidentate (Figs 30A-B); *2.* apex untoothed, simple, scooplike (Fig. 30C).

45. Gonostyle of ovipositor: *1.* small, linear, not projecting beyond apex of coxite (Fig. 30A,C); *2.* elongate, frequently clavate, projecting beyond apex of coxite (Fig. 30B).

46. Struts of ♀ 9th sternite: *1.* divergent towards base; *2.* convergent towards base.

PHYLOGENETIC METHODS. Analysis of this large dataset relied heavily on heuristic parsimony approaches. PAUP* (Swofford, 1998) was used for all tree searches, with characters treated as unordered throughout. An initial search saved no more than 50 shortest trees for each of 500 random taxon addition replicates. Restricting tree number and increasing addition replicates allowed a substantial amount of treespace to be explored preliminarily. This restricted search resulted in 800 trees (i.e. 16 of the 500 replicates found trees of equal, shortest length), which were then used as the basis of unrestricted branch-swapping. This unrestricted search was allowed to proceed for several hours, but was terminated due to memory restrictions when trees in memory hit 76,000, with nearly 20,000 trees still to swap. No trees shorter than the initial 800 were found.

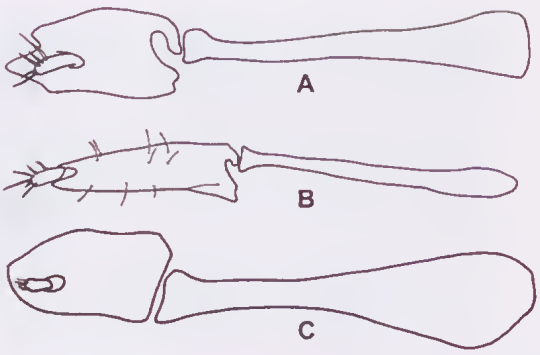

FIG. 30. Valvifers and gonocoxites of *Chlamydopsis* spp. A, *C. epipleuralis*. B, *C. rana*. C, *C. matthewsi*.

The smaller set of 800 trees was used as the basis for character reweighting, according to character rescaled consistency indices. A single reweighted search was carried out, with the restriction of 50 trees described above implemented. Although for both equally weighted and reweighted searches additional equally parsimonious arrangements might lead to a slight reduction in resolution of the consensus trees presented here, this search strategy should ensure that no shorter trees will be found. Decay indices were calculated (with all characters weighted equally) using the program TreeRot (Sorenson, 1999).

RESULTS. Two trees are presented from these analyses, the strict consensus of 76,000 trees resulting from the equally weighted, unrestricted search (C.I. = 0.2906, R.I. = 0.7593; Fig. 31), and the strict consensus of 10762 trees resulting from the reweighted, unrestricted search (Fig. 32) These two trees offer a relatively consistent picture of the broadest relationships in *Chlamydopsis*. At the basalmost levels of the tree, monophyly of Chlamydopsinae is strongly supported (6 decay steps). Within Chlamydopsinae a clade comprising *Chlamydopsis*, *Eucurtia*, and *Ectatommiphila* is supported by 2 decay steps, with an unusual, as yet undescribed, species from New Guinea as its sister group. Monophyly of *Chlamydopsis* itself is supported by a single decay step, with *Ectatommiphila* as its sister group. Relationships within *Chlamydopsis* are mostly supported by

TABLE 2. Character state data and consistency indices (calculated over the unweighted tree topology). a = 1,2; B = 1,3.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
C.I.	1.00	0.17	1.00	0.50	0.20	0.14	0.20	0.09	0.14	0.20	0.50	0.33	0.10	0.20	0.50	0.67	0.33	0.40	0.33	0.50	0.67	0.60	0.30	0.42	0.60	0.20	0.67	0.12	0.20	0.14	0.13	0.50	0.50	1.00	0.12	1.00	1.00	0.50	0.23	0.25	0.43	0.50	0.37	0.25	1.00	0.25	0.25
Stictostix frontalis	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3	6	4	3	3	1	1	2	1	1	1	1	1	1	1	5	1	1	1	3	1	1	1	1
nr. *Peploglyptus*	1	2	2	?	1	1	1	1	1	1	2	2	1	1	1	1	1	1	?	1	1	1	3	6	4	3	3	1	1	2	1	1	1	1	1	1	1	5	1	4	1	2	1	1	1	?
Ontlophilus flohri	1	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3	6	4	3	3	1	1	2	1	1	1	1	1	1	1	5	1	1	1	3	1	3	1	2
new genus1	1	1	2	?	1	1	1	1	2	1	1	1	1	1	1	2	1	1	2	1	1	3	6	4	3	3	1	1	1	1	1	1	2	2	2	1	1	3	1	1	1	1	?	?	?	?
new genus2	1	?	2	?	1	1	1	1	2	1	1	2	1	1	1	1	2	1	2	1	1	3	6	4	3	3	1	1	1	1	1	1	2	2	2	1	1	3	1	1	1	1	?	?	?	?
Pheidoliphila minuta	1	1	2	2	1	1	1	1	2	1	1	2	1	1	1	1	2	1	1	2	2	3	3	3	4	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	2	1	1	1	2
Orectoscelis dumogae	1	1	2	2	1	1	1	1	2	1	1	2	1	1	1	1	2	1	1	2	2	3	3	3	4	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	3	?	?	?	?
Orectoscelis obliquus	1	1	2	2	1	1	1	1	2	1	1	2	1	1	1	1	2	1	1	2	2	3	1	2	2	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	1	?	?	?	?
Ceratohister n. sp	1	1	2	2	1	1	1	1	2	1	1	2	1	1	1	1	2	1	1	2	2	3	1	2	2	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	1	?	?	?	?
new genus3	1	1	2	2	1	2	1	1	1	3	1	1	2	2	1	1	1	1	2	2	2	1	1	2	1	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	2	?	?	?	?
Eucurtia conata	1	?	2	?	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	1	1	1	1	2	1	1	1	2	2	1	1	2	1	?	1	1	?	?	?	?
Ectatommiphila opaca	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	1	1	2	2	2
Chl. striatipennis	1	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	3	4	3	4	1	2	2	2	2	2	1	1	1	2	1	1	1	4	4	2	1	1	?	?	?	?
Chl. leai	1	?	2	?	2	2	?	?	1	1	1	1	?	2	1	1	1	1	?	1	2	2	3	4	1	2	2	2	2	2	1	1	1	2	1	1	1	2	1	?	1	1	2	1	2	?
Chl. compressipes	1	2	2	2	2	2	2	1	1	1	1	1	2	2	1	1	1	1	?	1	2	2	3	4	1	2	2	2	2	2	1	1	1	2	1	1	1	2	1	?	1	1	2	1	2	2
Chl. pallida	1	2	2	2	2	2	2	2	1	2	1	1	2	2	1	1	1	1	1	1	2	4	3	5	3	2	2	2	2	2	1	1	1	2	1	1	1	4	3	2	1	1	1	1	2	2
Chl. rana	1	2	2	2	2	1	2	1	1	1	2	1	1	1	1	1	1	2	1	1	2	4	1	4	1	2	2	2	2	2	1	1	1	2	1	1	1	4	3	2	1	1	2	1	2	?
Chl. antennata	1	2	2	3	2	1	1	1	?	1	2	1	1	1	1	1	1	1	2	1	1	2	4	3	4	1	2	2	2	2	2	1	?	1	2	1	1	4	3	1	1	1	?	?	?	?
Chl. trichonota	1	2	2	3	2	1	1	1	?	1	2	1	1	1	1	1	1	1	2	1	1	2	4	3	4	1	2	2	2	2	2	1	?	1	2	1	1	4	3	1	1	1	?	?	?	?
Chl. reticulata	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	2	2	2	1	1	2	1	1	2	1	2	1	2	2	2	2
Chl. dimorpha	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	a	1	2	2	2	2	1	1	1	1	1	1	2	1	2	2	2	1	1	2	1	2	1	2	1	2	1	2	2
Chl. strigicollis	1	1	2	?	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	1	1	1	2	2	2	2	1	1	2	1	1	1	3	1	2	1	1	?	1	2	?
Chl. mormolyce	1	1	2	?	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	2	2	1	1	1	1	2	1	1	2	1	1	2	4	4	2	1	1	?	?	?
Chl. monteithi	1	1	2	2	2	2	1	1	2	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	1	2	2	2	2	1	2	1	2	2	2	1	1	1	1	2	1	1	?	?	?	?
Chl. setifera	1	1	2	?	2	2	1	1	2	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	1	2	2	2	2	1	2	1	?	1	2	2	1	1	1	1	2	1	1	2	1	2
Chl. lawrencei	1	1	2	2	2	2	1	1	2	1	1	1	2	2	1	1	1	2	1	1	2	2	2	1	1	1	1	2	2	2	2	1	?	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. pygidialis	3	?	2	2	2	2	2	1	2	1	2	1	2	3	2	1	1	1	?	1	2	2	2	2	1	1	1	1	1	2	3	1	1	2	1	1	1	2	1	1	2	1	2	?	?	2
Chl. carinicollis	3	?	2	2	2	2	2	1	2	1	2	1	1	2	3	2	1	1	?	1	2	2	2	2	1	1	1	1	1	1	2	3	1	1	2	1	1	1	2	1	1	2	1	2	?	?
Chl. serricollis	3	?	2	2	2	2	2	1	2	1	2	1	1	2	3	2	1	1	1	?	1	2	2	2	2	1	1	1	1	1	2	3	1	1	2	1	1	1	2	1	?	2	1	?	?	?
Chl. setipennis	1	?	2	?	2	2	1	2	1	2	1	1	2	?	1	1	1	?	1	1	2	2	2	2	1	1	1	1	1	1	2	3	1	1	2	1	1	1	2	1	?	2	1	?	?	?
Chl. convergens	3	1	2	2	2	2	2	1	1	2	1	1	2	2	2	1	1	1	1	1	2	4	2	1	1	1	1	2	2	2	2	1	1	2	1	1	1	2	1	2	2	1	2	1	2	1
Chl. coronis	3	1	2	2	2	2	2	1	2	1	2	1	1	2	3	2	1	1	1	1	2	4	2	1	1	1	1	2	2	2	2	1	1	2	1	1	1	2	1	2	2	1	?	?	?	?
Chl. erupta	3	1	2	2	2	2	2	1	2	1	2	1	1	2	3	2	1	1	1	2	1	2	4	2	1	1	1	1	2	2	2	2	1	1	2	1	1	1	2	1	2	2	1	?	?	?
Chl. transversa	3	1	2	2	2	2	2	1	2	1	1	1	2	3	2	1	1	1	1	1	2	4	2	1	1	1	1	2	2	2	2	1	1	2	1	1	1	1	1	2	2	1	?	?	?	?
Chl. longipes	2	1	2	1	2	2	?	?	2	1	1	1	2	?	1	1	2	1	2	1	2	4	2	?	1	1	?	2	2	2	2	1	1	1	2	1	2	2	4	4	?	1	1	2	1	2	?
Chl. inaequalis	2	1	2	?	2	2	1	2	1	1	1	1	1	1	1	1	1	1	2	1	2	4	2	1	1	2	2	2	2	2	2	1	1	2	1	1	2	2	4	2	2	1	1	?	?	?
Chl. agilis	2	?	2	2	2	2	2	1	2	1	2	1	1	2	?	1	1	1	1	?	1	2	4	2	?	1	1	2	2	3	2	2	1	1	2	1	1	2	4	2	?	1	1	?	?	?
Chl. ectatommae	1	2	2	2	2	2	2	1	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	1	1	1	2	2	2	2	?	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. kununurra	1	1	2	2	2	2	2	1	2	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	1	1	1	2	2	2	2	?	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. acutricha	1	1	2	?	2	1	1	2	2	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	1	1	1	2	2	2	2	?	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. myrmecophila	1	1	2	2	1	2	1	1	2	1	1	1	1	1	1	2	1	3	1	1	2	2	1	1	1	2	1	2	2	2	2	1	1	2	2	1	1	1	1	2	1	1	1	1	?	1
Chl. variolosa	1	1	2	2	2	1	2	1	1	1	1	1	1	1	1	2	1	3	?	1	2	2	1	1	1	2	1	2	2	2	2	1	2	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. mallee	1	1	2	2	2	2	2	1	2	1	1	1	1	1	1	1	1	3	1	1	2	2	1	1	1	2	1	2	2	2	2	1	2	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. pecki	1	1	2	2	2	2	1	1	a	1	1	1	1	1	1	2	1	3	1	1	2	2	1	1	1	2	1	2	2	2	2	1	2	1	2	2	1	1	1	1	2	1	1	?	?	?
Chl. loculosa	1	1	2	2	2	2	2	1	1	1	1	1	1	1	1	2	1	3	1	1	2	2	1	1	1	2	1	1	1	2	2	1	1	2	1	1	1	4	4	3	1	1	1	1	2	1
Chl. degallieri	1	1	2	2	2	2	2	1	a	1	2	1	1	1	1	1	2	1	3	1	1	2	2	1	1	1	2	1	1	1	2	1	1	2	1	1	1	4	4	3	1	1	1	1	?	?
Chl. papuae	1	?	2	2	2	2	2	?	?	1	1	1	2	2	1	2	1	3	1	1	2	2	1	?	1	2	1	2	2	2	1	1	?	1	2	1	?	?	1	?	?	1	1	?	?	?
Chl. jayawijaya	1	1	2	2	2	2	2	1	2	1	1	1	2	2	1	2	1	3	?	1	2	2	1	?	1	2	2	2	2	1	?	?	1	2	1	?	?	1	?	?	1	1	?	?	?	?
Chl. lucifer	1	1	2	2	1	2	1	2	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	2	1	1	1	2	2	1	1	2	2	1	1	1	1	2	1	1	1	?	?	?
Chl. bataviae	1	1	2	2	1	2	1	2	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	2	1	1	1	2	2	?	1	2	2	1	1	1	1	2	1	1	1	?	?	?
Chl. burnetta	1	1	2	2	2	2	1	1	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	1	4	4	2	1	4	1	2	2
Chl. zborowskii	1	1	2	2	2	2	1	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	2	2	2	2	1	1	2	2	2	1	1	2	1	1	1	4	4	2	1	4	?	?	?
Chl. pluriseta	1	1	2	2	2	2	2	1	1	1	1	2	2	1	2	1	3	1	1	2	2	2	1	2	3	2	2	1	1	2	2	2	1	1	2	1	1	1	4	4	2	1	4	?	?	?
Chl. contorta	1	1	2	2	2	2	2	1	1	1	1	1	1	?	1	2	1	3	1	1	2	2	1	1	2	2	2	1	1	2	3	2	2	?	1	2	1	1	4	4	2	1	4	?	?	?
Chl. pilosipes	1	1	2	2	2	2	2	1	1	1	1	1	2	2	1	2	1	3	1	1	2	2	1	1	2	2	2	1	1	2	3	2	2	1	1	2	1	1	1	1	2	1	4	?	1	2
Chl. bifoveocollis	1	?	2	?	1	2	1	?	1	1	1	1	2	2	1	3	1	2	1	1	2	2	1	1	1	2	1	1	1	2	1	2	1	?	1	2	2	1	1	1	?	1	1	?	?	?
Chl. nielseni	1	1	2	2	2	1	1	1	1	1	1	1	2	2	1	3	1	2	1	1	2	2	1	1	1	2	1	1	1	2	1	2	1	?	1	2	?	1	1	3	1	1	1	1	?	?
Chl. australis	1	1	2	2	1	2	1	1	?	1	1	1	?	1	1	3	1	2	1	1	2	2	1	1	1	2	1	1	2	2	2	1	?	1	2	1	1	1	1	2	1	1	?	?	?	?
Chl. lepida	1	1	2	2	1	2	1	1	?	1	1	1	1	1	1	3	1	2	1	1	2	2	1	1	1	2	1	1	2	2	1	?	1	2	1	1	1	1	1	2	1	1	?	?	?	?
Chl. epipleuralis	1	1	2	2	2	1	1	1	1	2	1	1	1	1	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	?
Chl. sculptus	1	1	2	2	2	1	1	1	1	2	1	1	1	1	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1	?	?	?	?
Chl. convexa	1	1	2	2	2	1	1	2	1	2	1	1	1	1	1	1	3	1	1	2	2	?	2	2	2	1	1	2	2	2	2	1	1	2	2	1	1	1	1	2	1	1	?	?	?	?
Chl. striatella	1	?	2	2	2	1	1	2	1	2	1	1	2	2	1	1	3	?	1	2	2	1	3	2	2	1	1	2	2	2	2	1	1	2	1	1	1	1	1	?	1	1	?	?	?	?
Chl. formicicola	1	1	2	2	2	1	1	2	1	2	1	1	2	2	1	1	3	1	1	2	2	1	3	2	2	1	1	2	2	2	2	1	1	2	1	1	1	1	1	2	1	1	2	1	2	2
Chl. dispersa	1	1	2	2	2	1	1	a	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	2	1	1	2	2	2	2	3	1	1	2	1	1	1	1	2	1	1	1	?	?	?
Chl. weiri	1	1	2	?	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	2	1	1	2	2	2	2	?	1	2	1	1	1	1	1	2	1	1	1	?	?	?
Chl. crowcrofti	1	1	2	2	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	?	1	2	1	1	1	4	2	2	1	1	?	?	?	?	?
Chl. latipes	1	1	2	2	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	1	1	2	1	1	1	4	2	2	1	1	2	1	2	2	2
Chl. macmillani	1	1	2	2	2	2	1	1	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	?	1	2	1	1	1	4	2	2	1	1	?	?	?	?	?
Chl. mallarbor	1	1	2	2	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	?	1	2	1	1	1	4	3	2	1	1	?	?	?	?	?
Chl. rotunda	1	1	2	?	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	4	3	2	2	1	1	2	2	2	2	1	1	2	1	1	1	1	1	2	1	1	2	1	2	2
Chl. latipennis	1	2	2	?	2	2	1	2	1	1	1	1	2	2	1	1	3	1	1	2	2	1	3	2	1	1	2	2	2	2	1	1	2	1	1	1	4	4	2	1	1	?	?	?	?	?
Chl. carinota	1	2	2	2	2	2	1	2	1	2	1	1	1	1	1	1	3	1	1	3	2	4	3	2	2	1	1	2	2	2	2	?	1	2	1	1	1	3	?	2	1	1	?	?	?	?
Chl. inquilina	1	1	2	1	2	1	1	2	1	2	1	1	1	1	1	1	3	1	1	2	2	1	3	2	2	1	1	2	2	2	1	1	1	2	1	1	1	4	1	1	1	1	2	1	2	1
Chl. detecta	1	?	2	?	2	1	1	2	1	2	1	1	1	1	1	1	3	?	1	2	2	4	3	2	1	1	2	2	2	3	?	1	2	2	1	1	2	1	1	2	1	1	b	?	?	?
Chl. storeyi	1	1	2	1	2	1	1	2	1	2	1	1	1	1	1	1	3	1	1	2	2	4	3	2	1	1	2	2	2	3	1	1	2	2	1	1	2	1	1	1	1	1	2	1	?	?
Chl. matthewsi	1	1	2	?	2	1	1	2	1	2	1	1	1	1	1	1	3	1	1	2	2	4	3	2	1	1	1	2	2	2	?	1	2	2	1	1	2	1	1	1	1	1	2	1	2	2
Chl. cavicollis	1	?	2	?	2	1	1	?	1	2	1	1	1	1	1	1	3	?	1	2	2	4	3	2	1	1	2	2	2	2	?	1	2	?	1	1	4	?	?	1	3	?	?	?	?	?
Chl. tuberculata	1	?	2	?	2	2	1	1	1	2	1	1	2	2	1	1	1	?	1	2	?	?	?	?	2	?	1	2	2	2	1	?	1	2	1	1	1	3	1	?	1	?	?	?	?	?
Chl. mareeba	1	1	2	?	2	1	1	1	1	1	1	1	1	1	1	1	3

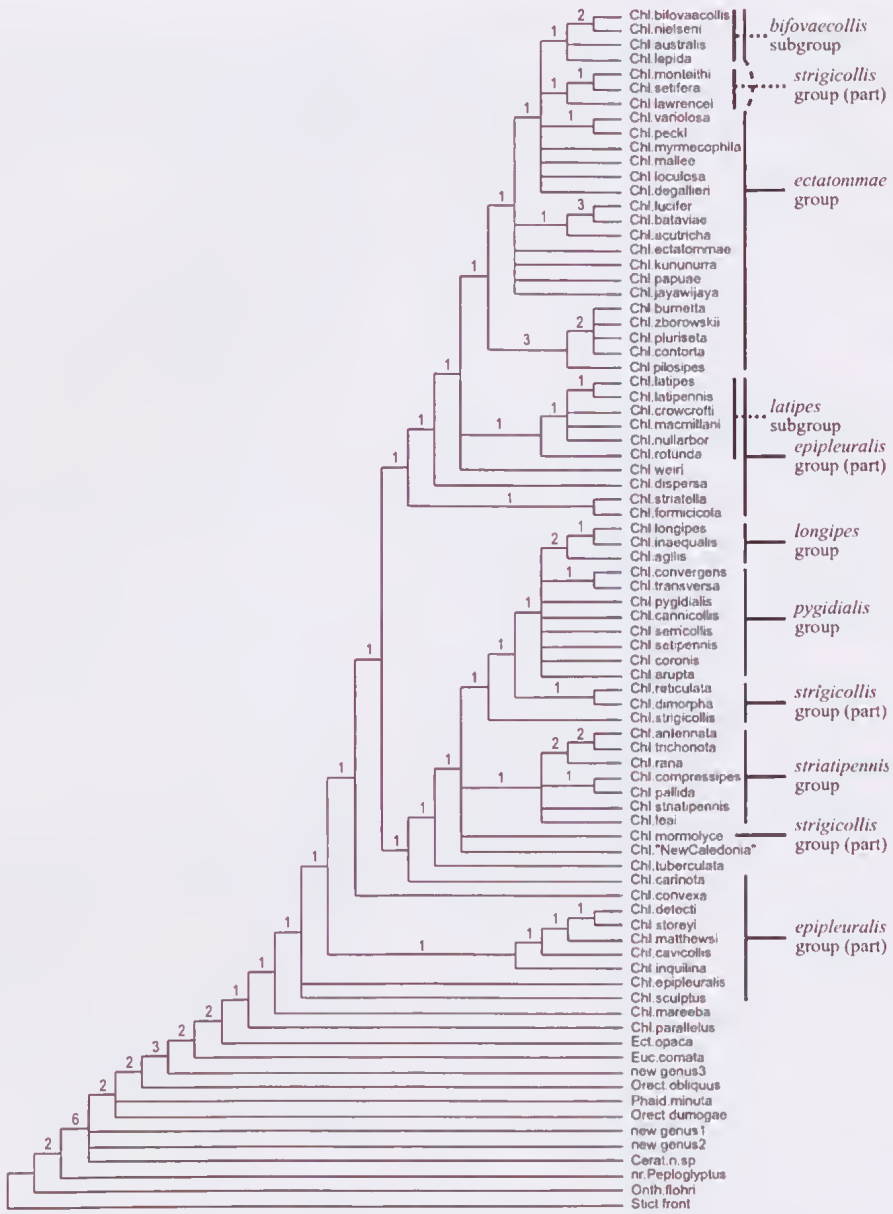

FIG. 31. Strict consensus of 76,000 equally parsimonious trees based on equally weighted analysis.

single decay steps, with a few species pairs and trios supported more strongly.

The species groups of *Chlamydopsis* proposed above are only roughly recovered. The *striatipennis* group is recovered in the equally weighted analysis, but in the reweighted analysis, the invariably monophyletic *longipes* group appears within it. In the equally weighted analysis the *longipes* group arises from within a mixed *strigicollis* group (partial) + *pygidialis* group clade. These two groups resolve together in both trees, with the *pygidialis* group consitituting a distinct clade only in the reweighted analysis. Three species tentatively suggested as related to the *strigicollis* group (*C. monteithi*, *C. setifera*, and *C. lawrencei*) do not resolve with this group in either analysis, but instead appear within the *ectatommae* group, in

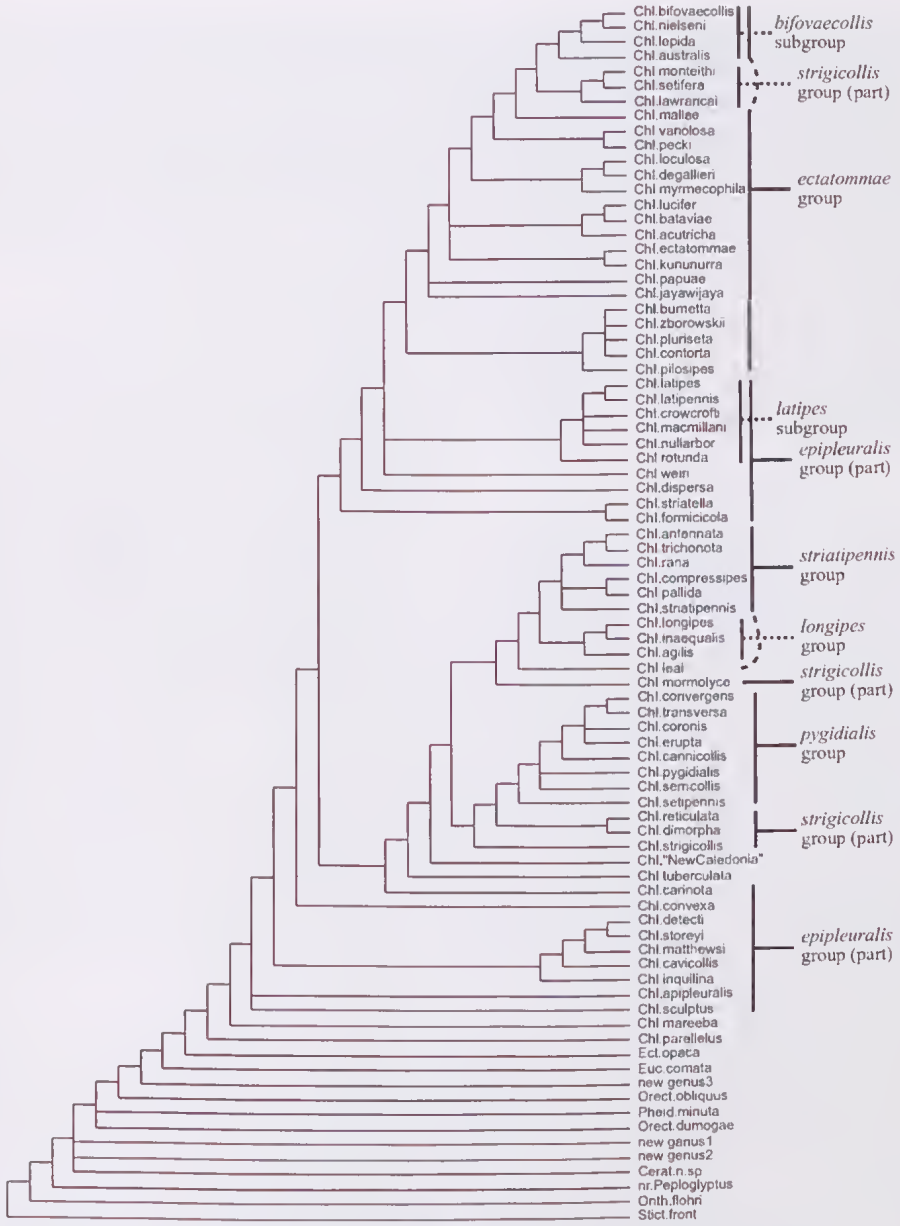

FIG. 32. Strict consensus of 10,762 equally parsimonious trees based on reweighted analysis.

the reweighted analysis as sister group to the four species of the *bifovaecollis* clade. While this alternative obviously merits closer investigation, it does require the loss of some significant features on the branch leading to these three, notably the divergent prosternal groove and the anterolateral pronotal groove. The *ectatommae* group itself appears as a coherent lineage in both equally weighted and reweighted trees (apart from, in both, the inclusion of the three *strigicollis* group species mentioned above). It is also worth noting that this clade includes the *bifovaecollis* subgroup (the inclusion of which here was suggested with some reservation).

A large clade, comprising most members of the *strigicollis* group, and the *striatipennis*, *longipes*,

and *pygidialis* groups, is recovered in both analyses, with several unplaced and *epipleuralis* group species at its base. The species designated as *epipleuralis* group are not recovered as a clade in either analysis. This group is scattered, with the *latipes* subgroup and a few others as a grade basal to the *ectatomnae* group, and the remainder as a grade basal to nearly all other *Chlamydopsis*. Of the species not placed in groups above, no relationships to other particular groups are strongly supported. *Chlamydopsis parallelus* and *C. mareeba* are resolved (sequentially) at the very base of *Chlamydopsis*, while *C. tuberculata* and the New Caledonian species appear near the base of the (*strigicollis* + *pygidialis* + *longipes* + *striatipennis* group) clade.

DISCUSSION

The forty new species of *Chlamydopsis* described in this treatment more than double the known species diversity, and greatly increase the known morphological and geographical range of the group. There are now 69 described species of *Chlamydopsis*, with representatives from every Australian state and both Papuan and Irian New Guinea (and New Caledonia). The species diversity in Queensland has emerged as clearly exceeding any other region, whereas species from near the populated areas of Victoria and New South Wales previously predominated. It is important to note, however, that while Queensland harbours the bulk of species diversity, phylogenetic diversity is more evenly distributed, with several species groups occuring primarily elsewhere (e.g. *longipes* group, *bifovaecollis* subgroup, *latipes* subgroup).

The previously unappreciated sexual dimorphism in *Chlamydopsis* is very interesting. Obvious sexual dimorphisms are generally rare in histerids. Those that have been documented have been primarily attributed to courtship (Caterino, 2002). The antennal club dimorphism (male antennal club twice or more the length of the female's — apparently first noted by Oke, 1923), nearly ubiquitous in Chlamydopsinae, obviously must have some olfactory significance. But it is impossible to say whether this relates to mate location, ant nest location (and perhaps differing dispersal tendencies between males and females), or some other factor. The significance of elytral and other textural dimorphisms is even more obscure. Body texture in myrmecophiles is often attributed to Wasmannian mimicry (Wasmann, 1889), in which guests' surface sculpturing (and, in some, shape and color) mimics that of the host, presumably a tactile disguise. Accepting that the underlying causes of this similarity have been controversial (Wilson, 1971), it is nonetheless observed in many species of Chlamydopsinae. Regardless whether this mimicry is directed at the hosts or at potential predators (Melver, 1987), the fact that intersexual morphological differences are observed in some Chlamydopsinae suggests that some differences in host relationships or activity patterns exist between them.

Outlines of the phylogeny of *Chylamydopsis* have begun to emerge from this study. Several apparently monophyletic groups of species have been identified, and although relationships among them need additional study, relationships within them are relatively consistent across analyses. Outgroup relationships to *Chlamydopsis* are in greatest need of additional analysis. The exact relationships of *Chlamydopsis* to *Eucurtia* and *Ectatomminiphila*, in particular, are unclear. It was considered initially likely that *Chlamydopsis* would prove paraphyletic with respect to these other two genera. However, with existing data, the monophyly of *Chlamydopsis* is supported. The relationships among more distant outgroups yield additional uncertainty with respect to relationships within *Chlamydopsis*. Apart from the New Guinean species ('new genus3'), all of the chlamydopsine outgroups here almost certainly constitute a clade (lacking a dorsally visible scutellum, and having a substantially elongated prothorax). It is unclear why these were not resolved as such in either analysis, and what effect this might have on resolutions elsewhere in the tree.

While the phylogenetic results obtained here do not justify a great deal of evolutionary exploration, one character reconstruction, especially, merits some discussion. These trees agree in reconstructing a deep prosternal groove, which departs from the margin laterally, as basal within *Chlamydopsis*. This groove is then subsequently weakened and lost in various other groups. This well developed and divergent groove is one of the most distinctive and unusual characters in *Chlamydopsis*, primarily of the *epipleuralis* group, and its evolution according to this scenario would be very surprising. This single result casts a shadow of doubt over much of the basal resolution in these trees.

One of the primary impediments to resolving relationships here has been the representation of so many species by only a single sex (or in some

TABLE 3. Published host records for species of *Chlamydopsis*. Only valid host species names are listed. See Table 1 for equivalence with originally published host names. Letters refer to literature cited: a = Lea, 1910; b = Lea, 1912; c = Lea, 1914b; d =Lea, 1918; e = Lea, 1919; f = Lea, 1925; g = Oke, 1923; h = King, 1869; i=this study. [1]The previously reported host has been split into these three species potentially sympatric with the beetle. [2]Lea reports that this species was collected in the vicinity of three species of ant; it was not possible to determine which was the host: *Myrmecia pyriformis*, *Ectatomma metallicum*, *Pheidole conflicta*. [3]These records were reported for the now synonymised *C. excavata* Lea.

Host subfamily	Ponerinae					Dolichoderinae						Formicinae		Myrmecinae			
Valid host species	*Rhytidoponero metallica*	*Rhytidoponera* sp.	*Rhytidoponera violacea*	*Rhytidoponera punctata*	*Pachycondyla lutea*	*Iridomyrmex gracilis*	*Iridomyrmex rufoniger* ssp.	*I. purpureus* *I. sanguineus* *I. forelli*[1]	*Iridomyrmex conifer*	*Iridomyrmex* sp.	*Dolichoderus ypsilon ypsilon*	*Notoncus ectotommoides*	*Camponotus oeneopilosus* ssp.	*Cremotogaster* sp.	*Meranoplus minor*	*Aphaenogaster longiceps longiceps*	*Aphoenogoster* sp.
C. striatipennis	f,g					g				e,f,g							
C. leai										g							
C. pallida															d		
C. reticulata[2]	f	e[3], g[3]															
C. strigicollis		g															
C. mormolyce				f													
C. pygidialis		g								f							
C. carinicollis		g														e	
C. serricollis	c																
C. setipennis												g					
C. longipes	a,b,g																
C. agilis	c,e,f																
C. ectatommae	b,d,g																
C. myrmecophila																	i
C. loculosa			f											f			
C. bifovaecollis					g					g							
C. epipleuralis						g				b,f							
C. sculptus										g							
C. formicicola													h,b,f				
C. latipes			f								e						
C. inquilina									e								
C. detecti								c									
C. tuberculata							b,g			e							

eases, perhaps, the inability to associate males with females). The sexual dimorphism in integumental texture, and, in some, trichome morphology, may prove to be important phylogenetic markers. But at present too many species have had to be scored as 'unknown' for them to have had much positive effect. Ovipositor morphology, likewise, shows interesting variation, but is missing in too many taxa to be as informative as it might. The fact that many species remain known only from types (which I have rarely risked to dissect) contributes further ambiguity to the dataset and results.

A summary of known host associations is presented in Table 3. These represent a broad phylogenetic range of ants, with hosts from four different subfamilies. Hosts in the Ponerinae predominate (13 species of *Chlamydopsis*), with Dolichoderinae a close second (9 species). It is perhaps surprising to note that several beetles use multiple hosts, even hosts in different subfamilies (e.g., *C. striatipennis* with *Rhytidoponera* and

Iridomyrmex; *C. latipes* with *Rhytidoponera* and *Dolichoderus*; *C. carinicollis* with *Rhytidoponera* and *Aphaenogaster*). Some of this may reflect local differentiation, and the host identifications given in the literature, for the most part, cannot be verified, but it appears that host specificity may be low for some species. This would have obvious implications in terms of chemical and behavioural integrating mechanisms. Similarly, little in the way of phylogenetic structure is evident with respect to host use, with apparently closely related species (e.g., *C. striatipennis*, *C. leai*, *C. pallida*) ranging across multiple host species and subfamilies. One possible phylogenetic distinction worth noting is the lack of host records for the ant *Pheidole*. Species of this ant genus are the preferred hosts for several species of *Pheidoliphila*, and this may represent a deep divergence between these two, broadly sympatric chlamydopsine genera.

While more large scale surveys will undoubtedly turn up additional interesting species of *Chlamydopsis*, the most pressing need at this stage is for more specific collecting. Locating these species in their natural environments will allow identification of hosts (known now for only a small fraction of species), facilitate association of sexes, and allow preservation of specimens for molecular work. At present only a single specimen of Chlamydopsinae adequate for DNA study has been obtained. It is unlikely that full phylogenetic resolution for the group will be achieved without combining morphological and molecular data. These ambiguities and limitations notwithstanding, the study of Chlamydopsinae is advancing rapidly. This is a fascinating and wonderful group of insects, and undoubtedly their continued study will yield many evolutionary insights.

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BARAHNA, A NEW SPIDER GENUS FROM EASTERN AUSTRALIA (ARANEAE: AMAUROBIOIDEA)

VALERIE TODD DAVIES

Davies, V.T. 2003 06 30: *Barahna*, a new spider genus from Eastern Australia (Araneae: Amaurobioidea). *Memoirs of the Queensland Museum* **49**(1): 237-250. Brisbane. ISSN 0079-8835.

Eight new species of *Barahna* gen. nov. are diagnosed, described and illustrated; these are *Barahna booloumba*, the types species and *B. brooyar*, *B. yeppoon*, *B. taroom*, *B. scoria*, *B. toonumbar*, *B. myall* and *B. glenelg*. The last is described from a single female. The genus ranges from mid-eastern Queensland, through northern and eastern New South Wales to southern Victoria. ❐ *Araneae, Amaurobioidea, Barahna, new genus, eastern Australia.*

Valerie Todd Davies, Queensland Museum, PO Box 3300, South Brisbane 4101, Australia; *10 September 2002.*

This genus is unique among described Australian amaurobioids in having an embolus with obvious 'pars pendula', a name coined by Comstock (1913). It refers to the membraneous part of the embolus in which the sperm duct is carried; it is reduced and not seen in most emboli. A further feature is the retrolateral apophysis on the male palpal patella. This occurs in at least two other, probably unrelated, Australian amaurobioids, *Paramatachia* and *Dardurus*.

Barahna spp. have been found in wet sclerophyll, vine scrub and open eucalypt forests from mid-east Queensland and eastern New South Wales. A single female specimen has been collected from southern Victoria suggesting that it also occurs in the coastal forests of that State. The spiders were found in sheet webs with a small retreat under rocks, logs or near the base of trees; they run on the underside of the web. Egg sacs containing 8 or more eggs are carried in the chelicerae. All species are named for their type locality.

METHODS

Most of the spiders were collected from pitfall traps (PF) or sieved litter samples. Notation of spines follows Platnick & Shadab (1975); measurements are in millimetres; the left palp is described and illustrated unless noted.

Abbreviations. Museums: AM, Australian Museum, Sydney; QM, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; WAM, West Australian Museum, Perth.

Collectors: DC, D. Cook; DW, D. Wallace; GBM, G. B. Monteith; GT. G. Thompson; MRG, M. R. Gray; RJR, R. J. Raven; SRM, S. R. Monteith; VED, V. E. Davies.

Location data: NP, National Park; SF, State Forest.

Anatomy: The usual abbreviations are used for body measurements, eyes and spinnerets. Abbreviations on illustrations are explained in the legends;.others in the text.

SYSTEMATICS

Barahna gen. nov.

TYPE SPECIES. *Barahna booloumba* sp. nov.

ETYMOLOGY. From the Aboriginal 'baran-barahn', spider in the Bundjalung language of northern New South Wales-Queensland border region.

DIAGNOSIS. Females may be distinguished from other cribellate amaurobioids by the presence of a pair of small dorso-posterior protuberances in the foveal region (Fig. 1B); these each have a small pale (unsclerotised) area (Fig. 7). Males may be distinguished by a membraneous pars pendula on the concave side of the embolus; as well, the palpal patella has a retrolateral apophysis (Fig. 1I).

DESCRIPTION. Small, 3-clawed cribellates (most less than 4.0). Coloration of the abdomen varies from pale to dark grey with a pattern of light spots in a vague chevron pattern (Fig. 1C). Carapace highest behind eyes; eyes directed forwards. From above, posterior eye row straight-slightly recurved, anterior row recurved. AME reduced. Two retromarginal and 4-6 promarginal chelicerai teeth (Fig. 1E); prolateral filamentous seta at base of fang longer than other setae. In the male the retromarginal teeth may be reduced in size and form a diagonal line with the promarginals. Labium about as long as wide; sternum longer than wide, pointed posteriorly

(Fig. 1D). Legs 4123 with bands of darker colour. Feathery hairs on legs and cephalothorax (Fig. 3D). Tarsal trichobothria in a single row, increasing in length distally; bothrium collariform; tarsal organ oval. Female genital atrium with medial thickening which is sclerotised basally (Fig. 1G); this sclerotisation provides a useful diagnostic character; it is not delineated in micrographs (Fig. 3A). Tiny lateral teeth, visible at high magnification, on posterior lateral edges of atrium. Long, coiled insemination ducts to posterior spermathecae (Fig. 3B). Male palp with oval tegulum, circular or semi-circular embolus with pars pendula; membranous conductor. A small, thin apophysis (? median) obscured by conductor (Figs 1K, 2D) may be present. Retrolateral tibial and patellal apophyses. Cribellum with two spinning fields in female; large broad colulus in male. Proximal calamistrum with one row of setae. Large ALS with two MAP in female, one and a nubbin in male (Fig. 4B). PMS with paracribellar spigots in female. Four simple tracheal tubes in abdomen, medians longer than laterals.

KEY TO *BARAHNA* SPP.

1. ♂, very long embolus encircling tegulum to terminate postero-retrolaterally. ♀, basal sclerite of epigynal atrium pointed (Fig. 1G) or rounded 2

   ♂, embolus describing about three-quarters of a circle to terminate mid-retrolaterally (Fig. 6A). ♀, basal sclerite of atrium flat-topped (Fig. 6D) 6

2. ♂, embolus arising postero-retrolaterally on tegulum (Fig. 2G). ♀, basal sclerite short, rounded (Fig. 2J) . . . . . *yeppoon*

   ♂, embolus arising antero- or mid-retrolaterally on tegulum. ♀, basal sclerite pointed, or slender and rounded (Fig. 5D). 3

3. ♂, embolus curled distally. ♀, basal sclerite pointed . . 4

   ♂, embolus slightly curved distally. ♀, basal sclerite slender or rounded. 5

4. ♂, embolus arising on mid-retrolateral tegulum . . . . . *booloumba*

   ♂, embolus arising on antero-retrolateral tegulum (Fig. 2A). . . . . *brooyar*

5. ♂, palpal patellal apophysis truncated (Fig. 5B). ♀, basal sclerite long, slender with rounded apex . . . . *taroom*

   ♂, palpal patellal apophysis digitiform. ♀, basal sclerite short, with small pointed apex (Fig. 5F) . . . . . *scoria*

6. ♀, basal sclerite as long as wide (Fig. 6D) 7

   ♀, basal sclerite longer than wide (Fig. 6L) . . . *glenelg*

7. ♂, patellal apophysis simple, digitiform. ♀, spermathecae small . . . . . *toonumbar*

   ♂, patellal apophysis long and bifid (Fig. 6G). ♀, spermathecae large . . . . . *myall*

Barahna booloumba sp. nov.
(Figs 1A-K, 3A-C, 4A-C, 7A, 8B; Table 1)

ETYMOLOGY. From the type locality Booloumba Ck, Conondale NP.

MATERIAL. HOLOTYPE. ♂, Booloumba Ck, Conondale Ra, southeast Queensland, 26°38'S, 152°39'E, 200m, rainforest, PF, 29 Nov. 1991-8 Jan. 1992, DC (QM S42241). PARATYPES. Southeast Queensland: ♀, same locality as holotype, PF, 13-18 Apr. 1976, RJR (QM S42242); ♂, 2♀ (QM S42243); 4♂, 2♀ (QM S42244); 2♂, ♀, Sunday Ck, Conondale Ra, 26°43'S, 152°34'E, 900m, rainforest, PF, 7 Jan.-2 Mar.1992, DC (QM S42245); 2♂, 2♀, same data as holotype (QM S42247); ♀, same locality as holotype, PF, 29 Nov. 1974-Feb. 1975, G. Maywald (QM S42248); ♂, Little Yabba Ck via Kenilworth, 26°36'S, 152°35'E, PF, 10 Aug.-9 Nov. 1974, GBM, SRM (QM S42249); 2♂, same data (QM S42250); 2♂, Sunday Ck, 900m, PF, 29 Nov. 1996-7 Jan. 1997, DC (QM S42251); ♂, Mapleton Falls NP, 26°38'S, 152°51'S, 500m, PF, 8 Jan.-3 Mar. 1992, DC (QM S47136); ♂, Ewan Maddock Dam, 26°48'S, 152°59'E, PF, M. Glover (QM S28512); 3♀, 3♂, Mt Coolum, 26°34'S, 153°05'E, PF, Jan. 1984, B. R. Jahnke (QM S42252); ♀, Kenilworth SF, 26°38'S, 152°39'E, wet sclerophyll forest, 5 May 1998, G. Milledge (AM KS71029); 2♂, same data (AM KS71030); ♂, ♀ (AM KS71031); 2♀, rainforest (AM KS71032); ♂, ♀, Conondale NP, 26°42'S, 152°37'E, wet sclerophyll forest, G. Milledge (AM KS71033); ♂, Little Yabba Ck, via Kenilworth, PF, 29 Dec. 1974-22 Mar. 1975, GBM, SRM (QM S45688); ♂, Cold Ck via Imbil, 26°27'S, 152°37'E, PF, 31 Dec. 1974-27 Mar. 1975, GBM, SRM (QM S45689); ♂, Sunday Ck, 26°40'S, 152°34'E, rainforest, PF, 18 Dec. 1996-20 Jan. 1997, GBM (QM S45690); ♂, Mary Cairncross Pk via Maleny, 26°43'S, 152°33'E, 240m, PF, 29 Dec. 1974-27 Mar. 1975, GBM, SRM (QM S45691); ♂, Dingo Ck via Traveston, 26°19'S, 152°48'E, 100m, PF 5, 9 Nov.-31 Dec. 1974, GBM, SRM (QM S45692); 2♂, Camerons Scrub, 27°31'S, 152°44'E, 50m, PF 7562, 11 Nov. 1998-13 Jan. 1999, GBM, DC, GT (QM S45693), ♂, ♀, Camerons Scrub, top of ridge, 27°30'S, 152°44'E, 160m, rainforest, sieved litter, 21 Nov. 1998, GBM, GT (QM S45718); 2 ♂, Mt Coolum, open forest, Jan. 1984, B.R. Jahnke (QM S45694); 9♂, ♀, Enoggera Reservoir, 27°27'S, 152°55'E, site 3, 100m, rainforest, PF 9214, 27 Jan.-15 Mar. 2000, GBM, J.Holt (QM S45728); 4♂, ♀, same locality, site 8, rainforest, PF 9068, 10 Nov.-21 Dec. 1999, GBM (QM S45729); 7♂, site 3, PF 9063, 16 Oct.-21 Dec. 1999, GBM (QM S45730); ♀, PF 9433, 15 Mar.-18 May 2000, GBM (QM S45731); 4♂, ♀, PF 9098, 21 Dec. 1999-27 Jan. 2000, GBM, J. Holt (QM S45732); 2♂, Mt Cabinet via Jimna, 26°43'S, 152°34'E, PF 29, 30 Nov.-29 Dec. 1974, GBM, SRM (QM S45733); ♂, same data, 29 Mar.-16 June 1975 (QM S45734); ♂, Deer Reserve, Kileoy, 26°59'S, 152°29, PF 30, 11 Jan.-29 Mar. 1975, GBM, SRM (QM S45735); ♀, same locality, 1 June-24 Aug. 1975 (QM S45736); 3♂, Tungi Ck, Jimna, 26°40'S, 152°28'E, PF, rainforest, 18 Dec. 1996-20 Jan. 1997, GBM (QM S45737); 3♂, same locality, PF28, 29 Dec. 1974-29 Mar. 1975, GBM, SRM (QM S45738); 2♂, Wrattens Camp Forestry via Widgee,

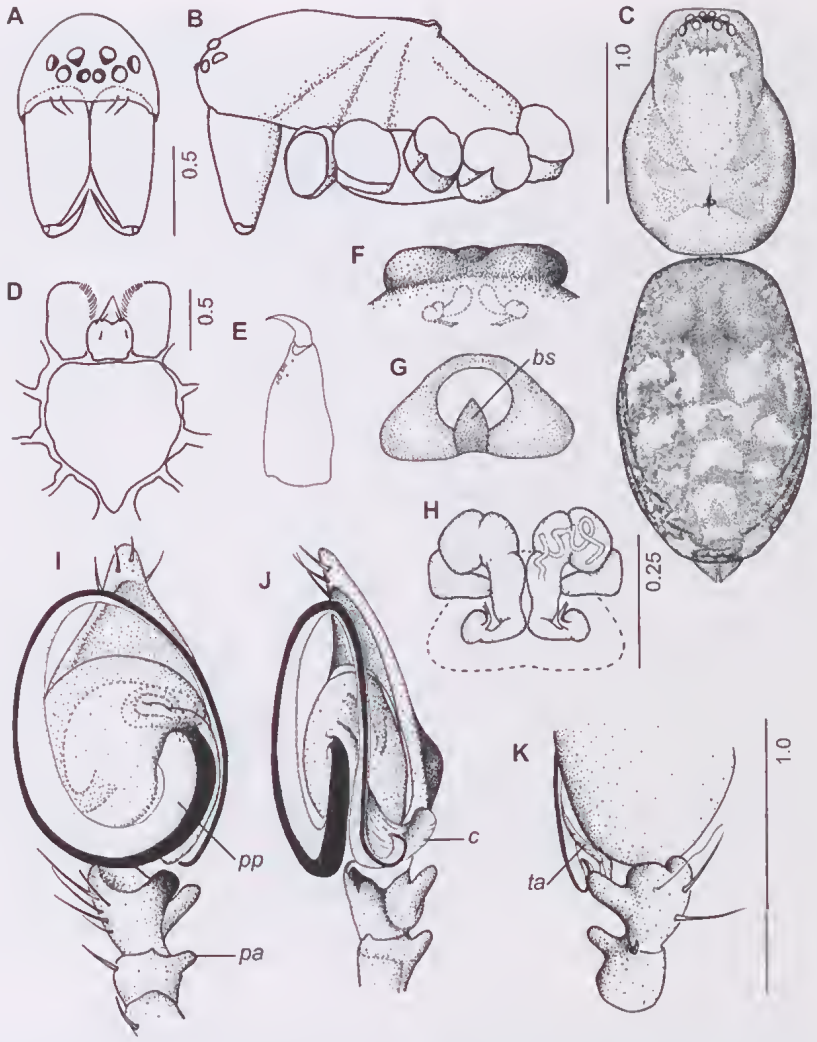

FIG. 1. A-K, *Barahna booloumba* sp. nov. A-H ♀; A, eyes, chelicerae (frontal); B, cephalothorax (lateral); C, body (dorsal); D, sternum, labium, maxillae; E, chelicera (ventral); F-H, epigynum (posterior, ventral, dorsal cleared). I-K, ♂ palp (ventral, retrolateral, dorsal). bs = basal selerite, e = conduetor, pa = patellal apophysis, pp = pars pendula, ta = tegular apohysis.

26°18'S, 152°20'E, PF 10, 11 Aug.-10 Nov. 1974, GBM, SRM (QM S45696); ♀, same data (QM S45697); 2♂, 8♀, Perrys Knob, 27°36'S, 152°36'E, vine scrub, 200m, sieved litter, 15 May 1999, GBM (QM S45695); ♀, ♂, same locality, PF 7564, 11 Nov. 1998-13 Jan. 1999, GBM, DC, GT (QM S45709); ♀, Mt Cotton, 27°37'S, 153°13'E, 200m, sieved litter, 13 Sept. 1997, GBM (QM S45714); ♀, Dandabah, Bunya Mts NP, 26°53'S, 151°36'E, notophyll vine forest with *Araucaria* emergents (hoop pine rainforest), 960m, litter, 29 Feb. 1976, VED (QM S45667); ♀ Paul Lentz Plain, Bunya Mts NP, 26°50'S, 151°33'E, hoop pine rainforest , PF, 7 Nov. 1994, Queensland National Parks (QM S45668); ♀, Bunya Mts NP, rainforest sieved litter, 2 Oct. 1979, GBM (QM S45669); ♂, ♀, Dandabah, Bunya Mts NP, under log with sheet web, 4 Sept.1974, RJR (QM S45670); ♂, Bunya Mts NP, 26°54'S, 151°37'E, 1006m, rainforest, PF19, 1974-1975, GBM, SRM (QM S45671); ♂, same locality, 960m, rainforest, sieved litter, 2 Oct. 1979, GBM (QM S45674); 4♂, ♀, Belthorpe, 26°50'S, 152°41'E, rainforest , PF,18 Dec.1996-20 Jan.1997, GBM (QM S55185); 2♂, 3♀, Redwood Pk,nr, Toowoomba, 27°34'S, 152°00'E, 7 Jan. 1986, GBM, SRM (QM S55186); 2♀, ♂, Cunninghams Gap NP, 28°03'S, 152°23'E, dry forest, sieved litter, 28 June 1991, D. Black (WAM 98/2081-3); ♂, Ravensbourne NP, 27°22'S, 152°11'E, 731m, rainforest, PF38, 10 Nov. 1974-12 Jan. 1975, GBM, SRM (QM S55188) ; 9♀, juv.♂, Upper Brookfield nr Brisbane, 27°28'S, 152°52'E,

notophyll rainforest with *Araucaria*, litter, 22 May-11 Aug. 1976, RJR, VED (QM S55190); 3♂, 2♀, same location, 28 Jan. 1982, RJR, VED (QM S55191); ♂, ♀, PF, 23 Dec. 1980-22 Jan. 1981, RJR, VED (QM S55194); 4♀, 17 July 1981 (QM S55195); ♀ with egg sac under log, same data, 2 Sept. 1981 (QM S55198); 3♀, 2♂, PF, 8-23 Apr. 1981 (QM S55199); 3♂, Gold Ck nr Brisbane, 27°28'S, 152°53'E, PF, 31 July-1 Sept. 1981, RJR, VED (QM S55200); ♂, Flinton Hill nr Ipswich, 120m, PF 52, 20 May-11 Aug. 1976, GBM, SRM (QM S55201); ♂, Mt Glorious, 27°20'S, 152°45'E, 29 Sept. 1973, RJR (QM S55202); 2♀, Jollys Lookout, Boombana NP, open forest, litter, 30 June 1991, D. Black (WAM 98/2090-2); ♀, Brisbane Forest Pk nr Boombana, closed forest, PF, 17-24 July 1987, Rhonda Grundy (QM S55203); 2♂, Mt Mee via Samford, 27°05'S, 152°41'E, rainforest, PF14, 9 Nov. 1974-11 Jan. 1975, GBM, SRM (QM S55204); 2♀, Mt Mee SF, 27°06'S, 152°42'E, 550m, rainforest, stick brushing, 28 Feb. 1979, GBM (QM S55205); ♂, ♀, Mt Mee, Upper Neurum Ck, 27°05'S, 152°42'E, rainforest, sieved litter, 3 Sept. 1979, GBM (QM S55206); ♂, Mt Mee, Plateau Site, rainforest, PF 89, 8 Oct. 1977-20 Jan. 1978, GBM (QM S55207); ♂, Cainbable via Lamington NP, 28°10'S, 153°07'E, 762m, PF 57, 28 Sept. 1975-31 Jan. 1976, GBM, SRM (QM S 55208); 2♂, Bahrs Scrub, 27°46'S, 153°10'E, 100m, rainforest, PF, 10 Dec. 1991-21 Jan. 1992, DC (QM S25032). OTHER MATERIAL. New South Wales: ♂, New Brighton Beach via Brunswick Heads, 28°31'S, 153°33'E, 10m, rainforest, PF 39, 3 Aug.-16 Nov.1975, GBM, SRM (QM S55189).

DIAGNOSIS. Retrolateral origin of embolus; palpal patellal apophysis digitiform (Fig. 1K). Sclerotised base of epigynal atrium pointed anteriorly. Dorso-posterior protuberances in foveal region rounded with small posterior unsclerotised areas (Fig. 7A).

DESCRIPTION. *Male*. CL1.9, AL 1.9. Ratio of AME: ALE: PME: PLE is 6:10:10:10. Legs 4123 (Table 1). Notation of spines. Femora: I, D110, P001; II, D111, P001, R001; III, D101, P101, R001; IV, D101, P001, R001. Patellae: III, D001. Tibiae: I, P011, V102, R011; II, D001, P101, V102, R101; III, D001, P101, V012, R101; IV, P101, V112, R101. Metatarsi spined with distal whorl 4-5 spines.

♂ palp (Fig. 11-K). Embolus with membraneous pars pendula arising retrolaterally and encircling tegulum clockwise, ending in a distal curl postero-retrolaterally. Membraneous conductor arising just anterior to embolus, broadening distally; small membraneous thin finger-like tegular apophysis arising dorsal to embolus and obscured by conductor (Fig.2D). Retrolateral tibial apophysis (RTA) with curved blunt ventro-retrolateral and digitiform retrolateral branches. Smaller digitiform patellal apophysis.

Other males ranged from 3.0-3.8 in length.

Female. CL 1.6, AL 1.8. Ratio of AME: ALE: PME: PLE is 6:9:9:9. Legs 4123 (Table 1). Carapace with two small dorso-posterior protuberances on fovea. Notation of spines. Femora: I, D101, P001; II, D101, P001, R001; III, D101, P001, R001; IV, D101, P001, V010, R001. Patellae: III, D001. Tibiae: I, P011, V102; II, P011,V010, R101; III, D001, P011, V012, R011; IV, D101, P011 ,V112, R011. Metatarsi spined with distal whorl of 4-5 spines.

Epigynum (Figs 1F-H, 3A,B). Gonopores at base of atrium; insemination ducts proceed laterally then coil (two or three coils) forward to turn back to enter spermathecae. Tiny lateral teeth on posterior lateral edges of atrium; sclerotised basal part of atrium pointed.

Spinnerets (Fig. 4A,C). ALS with two major ampullate spigots, about 14 piriform spigots and at least two tartipores. PMS with large anterior spigot (minor ampullate), two posterior spigots (cylindrical) and eight others. Four of these have one or two strobilate shafts (paracribellars) and four have single plain shafts (aciniform). PLS with two large (cylindrical) and four aciniform spigots.

Females ranged in length from 3.5-3.9.

DISTRIBUTION. *B. booloumba* (Fig. 8B) has been collected from many localities in southeastern Queensland and from Brunswick Heads in coastal New South Wales.

TABLE 1. *Barahna booloumba* ♂(♀) leg lengths.

	Leg I	Leg II	Leg III	Leg IV
Femur	1.7 (1.5)	1.5 (1.3)	1.3 (1.2)	1.9 (1.5)
Patella X Tibia	2.3 (1.9)	1.8 (1.4)	1.6 (1.3)	2.3 (1.8)
Metatarsus	1.6 (1.3)	1.3 (1.0)	1.3 (0.9)	1.9 (1.5)
Tarsus	1.0 (0.8)	0.8 (0.7)	0.6 (0.6)	0.8 (0.8)
Total	6.6 (5.5)	5.4 (4.4)	4.8 (4.0)	6.9 (5.6)

Barahna brooyar sp. nov.
(Figs 2A-F, 8B)

ETYMOLOGY. From the type locality Brooyar SF.

MATERIAL. HOLOTYPE. ♂, Brooyar Fire Tower via Gympie, southeast Queensland, 26°10'S, 152°28'E, 457m, rainforest, PF54, 23 Aug. 1975-29 Feb. 1976, GBM, SRM (QM S45722). PARATYPES. Southeast Queensland: ♀,♂ same data (QM S45723); ♂, same locality and collectors, 29 Feb.-25 Apr. 1976 (QM S45724); 7♂, Marys Ck, Forestry via Gympie, 26°16'S, 152°33'E, 240m, PF9, 11 Aug.-10 Nov. 1974, GBM, SRM (QM S45725); ♂, same locality and collectors, 16 June-28 Aug. 1975 (QM

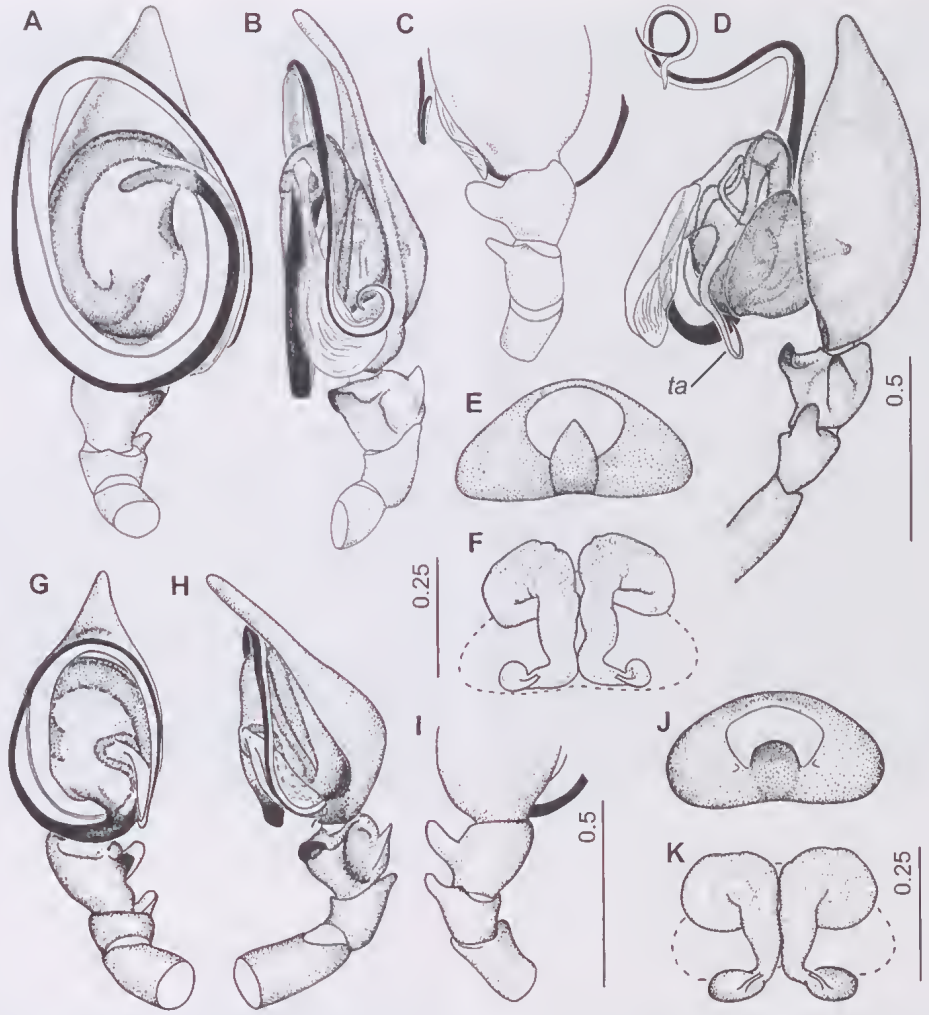

FIG. 2. A-K, *Barahna* spp. nov. A-F, *B. brooyar* sp. nov. A-D, ♂ palp (ventral, retrolateral, dorsal, expanded in KOH); E,F, ♀ epigynum (ventral, dorsal cleared). G-K, *B. yeppoon*. G-I, ♂ palp (ventral, retrolateral, dorsal); J,K, ♀ epigynum (ventral, dorsal cleared). ta = tegular apophysis.

S45726); ♀, 28 Mar.-16 June 1975 (QM S45727); ♂, 11 Aug.-10 Nov. 1974 (QM S55209).

DIAGNOSIS. In males the embolus arises near the anterior retrolateral edge of tegulum (Fig. 2A) obscuring the anterior coil of the sperm duct, unlike *B. booloumba* where it arises mid-retrolaterally (Fig. 1I) and the sperm duct is clearly seen.

DESCRIPTION. *Male*. CL 2.0, AL 1.8. Ratio of AME: ALE: PME: PLE is 6: 9: 8: 9. Legs 4123. I, 6.9; II, 5.6; III, 4.6; IV, 7.3. Notation of spines somewhat variable within left and right sides of spider and between specimens. Femora: I, D011, P001; II, D001, P001; III, D110, P001, R00(1); IV, D100, R00(1). Tibiae: I, P011, V2(2)2, R011; II, D001, P0(0)1, V112, R101; III, D(1)0(0), P101, V(1)12, R011; IV, D00(1),P0(0)1, V(1)12, R(0)1(1). Metatarsi spined with dorsal whorl of 4-5spines.

♂ palp (Fig. 2A-D). Embolus arising near anterior edge of tegulum obscuring coil of sperm duct; embolus curled distally. RTA digitiform, ventro-RTA blunt, sclerotised. Patellal apophysis digitiform.

Males ranged from 2.7-3.9 in length.

Female. CL 1.9, AL 2.1. Legs: I, 6.7; II, 5.3; III, 5.0; IV -. Notation of spines similar to male with

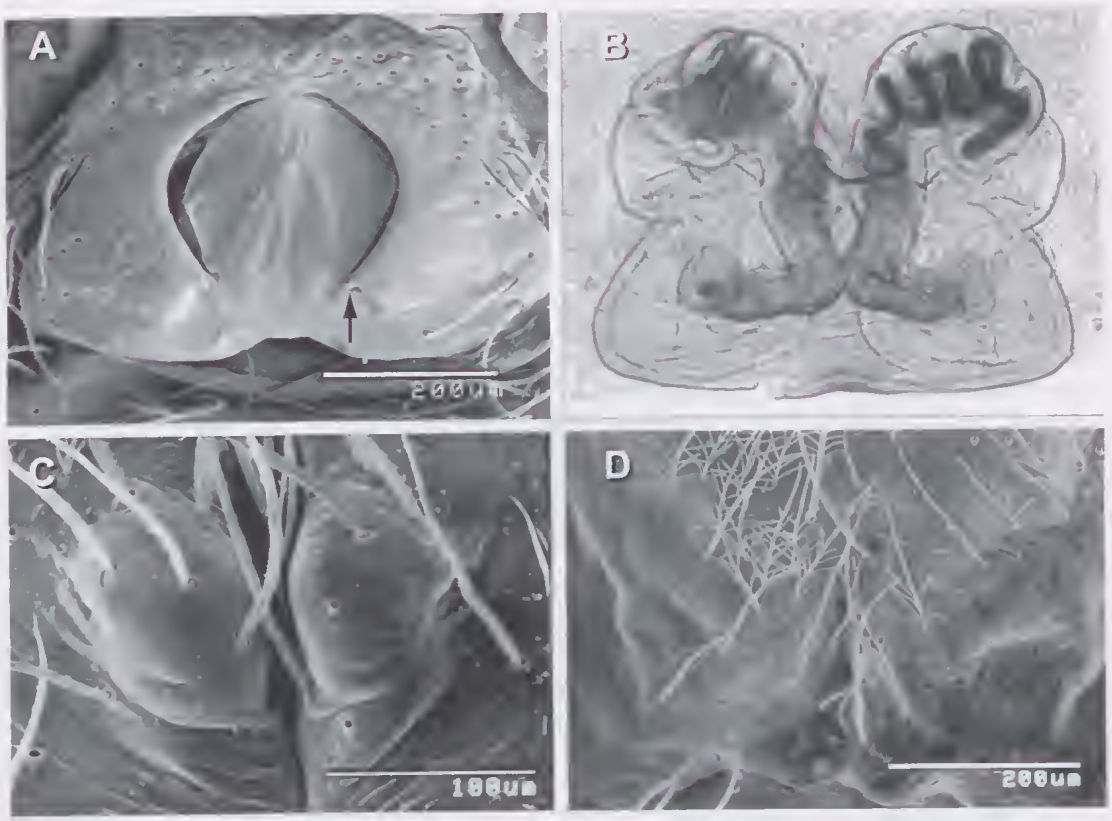

FIG. 3. A-D, *Barahna* spp. nov. A-C, *B. booloumba*; A, ♀ epigynum (ventral, arrow to lateral teeth); B, epigynum (dorsal cleared; photo-micrograph showing embolus in insemination duct); C, protuberances on fovea; D, *B. yeppoon*, ♀ foveal area.

fewer spines on ventral tibiae: III, 012; IV, V111. Epigynum (Fig. 2E,F). Sclerotised base of atrium long and pointed.

The other female was 4.0 long.

DISTRIBUTION. *B. brooyar* (Fig. 8B) has been collected from only two localities in southeastern Queensland.

Barahna yeppoon sp. nov.
(Figs 2G-K, 3D, 4D, 8A)

ETYMOLOGY. From the type locality, Yeppoon.

MATERIAL. HOLOTYPE. ♂, Yeppoon, Meikleville Hill, Queensland, 23°06'S, 150°43'E, vine thicket, PF, 21 Apr.-18 July 1990, DW, RJR (QM S34450). PARATYPES. Queensland: 3♀, Yeppoon, Iwasaki Rd, vine thicket, PF, 18 July-23 Oct. 1990, DW, RJR, K. Williams (QM S33577); ♂, same locality as holotype, PF, 18 July-23 Oct. 1990; DW, RJR, K. Williams (QM S34096); ♂, 7♀, 6.2km W Yeppoon, 23°10'S, 150°43'E, semi-dry scrub, 27 May 2000, G. Milledge, H. Smith (AM KS67481); ♂, same data (AM KS67482); ♂, same data (AM KS67483); 2♂, Frenchville, 23°20'S, 150°34'E, open forest, PF, 21 Apr.-18 July 1990, DW, RJR (QM S34443); ♀, Rosslyn Head, 23°10'S, 150°47'E, vine thicket, PF, 18 July-23 Oct. 1990, DW, RJR, K. Williams (QM S25580); 2♂, same data (QM S25589); 2♂, same locality, PF, 20 Apr.-18 July 1990, DW, RJR (QM S34246); 2♂, Bondoola, 23°11'S, 150°41'E, open forest, PF, 20 Apr.-July 1990, DW, RJR (QM S22196); ♀, same locality, PF, 18 July-23 Oct. 1990, DW, RJR, K. Williams (QM S46237); ♂, Nob Ck, 23 Sept. 1993, DW (QM S34427); ♂, Olsen's Caverns, 23°10'S, 150°28'E, open forest, PF, DW, RJR, K. Williams (QM S41239); ♀, Mt Archer, 23°20'S, 150°35'E, 650m, open forest, PF, 4 Sept.-11 Nov. 1991, DW, RJR (QM S46022); ♀, Mt Chalmers, 23°10'S, 150°38'E, open forest, PF, Oct. 1990-21 Mar. 1991, DW, RJR, K. Williams (QM S24551); ♂, Fairlies Knob, 25°32'S, 152°19'E, 120m, vine scrub, PF, 21 July-20 Oct. 2000, DC, J. Wright, E. Vanderduys, 9463 (QM S55257); ♀, Teewah Ck, Cooloola, 25°57'S, 153°06'E, 14 Sept. 1973, RJR (QM S55245); ♀, Cooloola, rainforest, under rotten log, 21 Aug. 1970, E.C. Dahms (QM S55246); ♂, ♀, Cooloola, high dune, PF, Oct. 1978, C. Plowman (QM S55248); ♀, 7♂, Orchid Beach, Fraser I., 24°58'S, 153°19'E, PF, 20 Aug.-17 Dec. 1997, RJR, P.

Fishburn, P. Lawless (QM S43420); ♂, Fraser I., Feb. 1971, ANU (AM KS34841); ♂, 3♀, Fraser I., Orchid Beach, 24°58'S, 153°18'E, PF, 20 Aug.-17 Dec. 1997, RJR, P. Lawless (QM S43453); 3♂, ♀, same data (QM S41776); 3♂, 3♀, Fraser I., heath, *Banksia*, eucalypt, PF, 7 Mar.-1 Oct. 1996, RJR (QM S31275); ♂, Mt Coot-tha, 27°29'S, 152°57'E, PF, 17 Dec. 1996, RJR (QM S41181); ♀, Slaughter Pk, Mt Coot-tha, 22 May 1978, VED, RJR (QM S55261); ♀, Mt Coot-tha, 1 Sept. 1973, RJR (QM S55262); ♂, Mt Nebo, 27°24'S, 152°47'E, PF, mixed sclerophyll, 16 Oct. 1978, A. Rozefelds (QM S55263); ♂, Mt Glorious, 27°20'S, 152°45'E, sieved litter, 20 June 1991, D. Black (WAM 98/2101); 4♂, Cooloola Village, 26°00'S, 153°00'E, PF, 8 July-4 Dec. 1998, RJR, P. Lawless (QM S53390); ♂, Camerons Scrub, 27°30'S, 152°44'E, 90m, PF, 7557, vine scrub, 11 Nov. 98-13 Jan. 1999, GBM, DC, GT (QM S45715); ♂, Bunya Mts, Paradise, 26°52'S, 151°35'E, pyrethrum pine trunks 5026. GT (QM S45672); ♂, Marlaybrook, Bunya Mts, semi-evergreen thicket, 1-6 Mar. 1976, RJR, VED (QM S45673); ♀, Kroombit Tops, open forest with *Casuarina*, on sand, 23-25 Feb. 1982, GBM, RJR, GT (QM S45686); ♂, Calliope Ra. Kroombit Tops, 24°22'S, 151°00'E, PF 13, open forest, 12-18 Dec. 1983, GBM, VED, GT, J. Gallon (QM S55264); 2♂, ♀, same data, PF14 (QM S55265); ♀, Jimna SF, 26°40'S, 152°28'E, under logs, 31 May 1978, K. McDonald, S. Crafter (QM S45706); 10♂, top of Blackbutt Ra., via Benarkin, 26°52'S, 152°12'E, PF16, rainforest 396m, 17 Aug.-10 Nov. 1974, GBM, SRM (QM S55268); 4♂, same data (QM S55269); ♂, Base of Blackbutt Ra., 26°52'S, 152°11'E, 240m, PF 15, rainforest, 17 Aug.-10 Nov. 1974, GBM, SRM (QM S55270); 2♀, Fairlies Knob, 25°31'S, 152°17'E, 300m, PF9974, hoop pine scrub, 20 Dec. 2000-22 Mar. 2001, DC, GBM (QM S55271); 3♂, 4♀, same locality, PF9464, vine scrub, 21 July-20 Oct. 2000, DC, J. Wright, E. Vanderduys (QM S55272); ♂, same data, 120m, PF9463 (QM S55273); 2♂, One Tree Hill, 25°17'S, 151°55'E. 180m, vine scrub, PF9000, 27 Sept.-14 Dec. 1999, DC (QM S55274); ♀, Nipping Gully, 25°41'S, 151°25'E, 150m, PF7259, open forest site 3, 27 Aug.-9 Oct. 1998, GBM (QM S55275); ♂, same locality, 240m, PF 7707, 26 Jan.-2 June 1999, GBM, GT (QM S55276); 2♂, "Stockhaven", 25°48'S, 151°59'E, 450m, rainforest, PF 7515, 10 Oct.-19 Dec. 1998, GBM, C. Gough (QM S55277); ♂, Nangur SF, 26°08'S, 151°59'E, site 2, 320m, PF, rainforest, 29 July-23 Oct. 1995, GBM (QM S42320); ♂, Yarraman, 26°50'S, 152°03'E, 520m, rainforest, PF 17, 17 Aug.-10 Nov. 1974, GBM, SRM (QM S55278); 3♂, McAfees Lookout, 27°26'S, 152°52'E, 150m, PF7825, wet scleroplyll, 6 July-18 Oct. 1999, GBM (QM S55280); 2♂, 3♀, Camira, 27°38'S, 152°55'E, open forest, PF, 30 July-Oct. 1990, RJR (QM S19622-3); ♂, Camira, under log, 22 Jan. 1997, RJR (QM S55256); ♀, Rochedale SF, 27°34'S, 153°08'E, PF, 1-23 Oct. 1979, VED, RJR (QM S55282); ♂, same locality and collectors, PF, 20 Sept.-11 Oct. 1979 (QM S55283); ♀, 17 Jan. 1980 (QM S55285); ♀, PF, 30 Aug.-6 Sept. 1979 (QM S55286); ♂, Bulburin Barracks, 24°32'S, 151°28'E, 580m, rainforest, pyrethrum 7816, 8 Oct. 1999, GBM (QM S45680); 2♀, Bulburin SF, 540m, small sheet webs, 25-28 March 1977, RJR, VED (QM S45676); ♂, top of range, Bulburin SF, 24°33'S, 151°33'E, 600m, PF33, 5 Oct.-30 Dec. 1974, GBM, SRM (QM S45679); ♀, with egg sac, Bulburin Forest nursery, 24°31'S, 151°29'E, 580m, rainforest under log, 21 Mar. 1975, MRG, C. Horseman (AM KS71038); ♂, Rundle Ra., 23°39'S, 150°59'E, semi-evergreen vine thicket, 30m, 24-31 Mar. 1975, R. Kohout, VED (QM S45704); 12♂, 12♀, Mt Goonaneman, 25°26'S, 152°18'E, litter, 3-7 Nov. 1980, RJR, VED (QM S45701); 4♂, ♀, Rocky Pt., 10km S Round Hill Hd, 24°14'S, 151°56'E, 60m, PF71, 28 Aug.-15 Dec. 1976, GBM, SRM (QM S45699). OTHER MATERIAL. New South Wales: ♀, ♂, Carrai SF nr Carrai Bat Cave, 31°01'S, 152°20'E, Jan. 1993, MRG (AM KS34522).

DIAGNOSIS. In males the embolus arises retro-posteriorly whereas it is retrolateral in *B. booloumba* and antero-retrolateral in *B.brooyar*; palpal patellal apophysis blunt, inturned and shorter than *B. booloumba* and *B.brooyar* in which it is digitiform. Sclerotised base of epigynal atrium is bluntly rounded whereas it is sharply pointed in *B. booloumba*.

DESCRIPTION. *Male*. CL 2.0, AL 2.0. Ratio of AME: ALE: PME: PLE is 6:10:9:10. Legs 4123. I, 8.4; II, 7.0; III, 6.3; IV, 8.5. Notation of spines. Femora: I, D110, P001; II, D111, P001, R001; III, D110, P011, R001; IV, D110, P001, R001. Patellae: III, D001. Tibiae: I, P111, V222, R011; II, D001, P001, V221, R011; III, P011, V222, R011; IV, P111, V212, R101. Metatarsi spined with distal whorl of 5 spines.

♂ palp (Figs 2G-I, 4D). Embolus arises retro-posteriorly encircles tegulum to a distal curve postero-retrolaterally. Patellal apophysis short, blunt, slightly incurved.

Males ranged in size from 3.1-4.0.

Female CL 2.2 AL 2.3, Ratio AME: ALE: PME: PLE is 7:11:10:11. Legs 4123. I, 8.2; II, 6.9; III, 6.3; IV, 8.3. Notation of spines similar to ♂ but fewer on ventral tibiae: III, V120; IV, V120. Epigynum (Fig. 2J,K) sclerotised base of atrium short with blunt-rounded apex. Small lateral teeth present.

Females ranged from 3.1-4.9 (average 4.0).

Scanning electron micrograph of the foveal region (Fig. 2D) revealed a pattern of dark spots which suggested pheromone production, however these were also found in the male. Further investigation of the pale areas near the fovea did not show any pores.

DISTRIBUTION. *B. yeppoon* (Fig. 8A) has been found from mid-eastern to southeastern Queensland. A male and female were collected

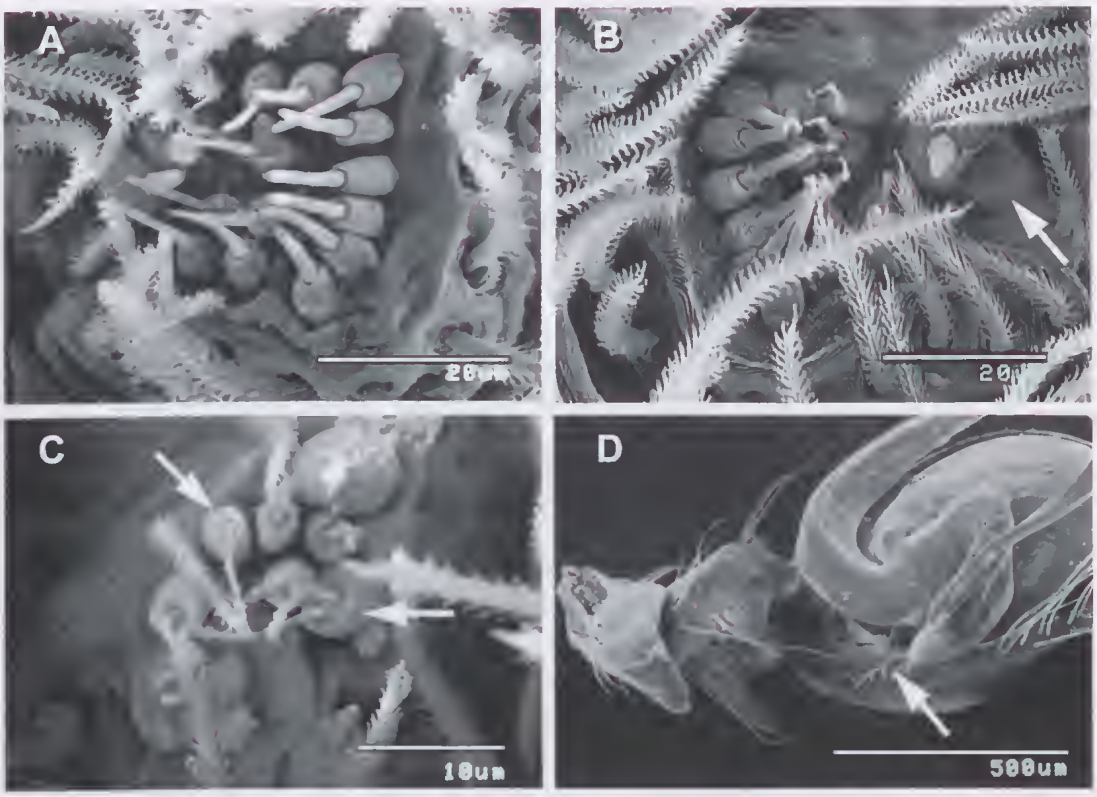

FIG. 4. A-D, *Barahna* spp. nov. A-C, *B. booloumba* spinnerets; A, ♀ ALS (left); B, ♂ ALS (right), arrow to nubbin; C, ♀ PMS, arrows to paracribellar spigots; D, *B. yeppoon*, ♂ palp, arrow to tegular apophysis.

from near the bat caves in Carrai SF, New South Wales.

Barahna taroom sp. nov.
(Figs 5A-E, 8C)

ETYMOLOGY. From the type locality, Taroom.

MATERIAL. HOLOTYPE. ♂, Taroom, 9km N, southeast Queensland, 25°27'S, 150°08'E, PF, June-11 Sept. 1996, P. Lawless, H. Janetzki, D. Potter (QM S36452). PARATYPES. Queensland: ♀, Taroom, Dawson R., Nathan Gorge, riverine forest, PF, 12 Sept.-13 Jan. 1997, P. Lawless (QM S37019); ♂♀, same data (QM S37024); ♀, same data (QM S37034); 4♂ (QM S37049); 3♂, Taroom District, Nathan Gorge, riverine forest, PF107, 13 Nov. 96-13 Jan. 1997, P. Lawless (QM S36615); 2♂, same locality, PF010, 15 June-12 Sept. 1996, P. Lawless (QM S37265); 4♂, same data (QM S36860); 2♂, same locality, PF107, 13 Nov. 96-13 Jan. 1997, P. Lawless (QM S37076); 5♂, ♀, same data (QM S37096); ♂, Taroom District, 25°25'S, 150°01'E, Boggomoss no.19, PF105, 18 June-9 Sept. 1996, P. Lawless (QM S36811). ♂, Mt Zamia, 24°06'S, 148°05'E, vine scrub, 360m, PF9818, 27 Oct.-17 Dec. 2000, DC, GBM (QM S55215); ♂, Mt Gavial, 23°36'S, 150°29'E, open forest, 400m, PF7486, 17 Dec. 98-14 Mar. 1999, DC (QM S55217); ♂, Mt Hopeful, 23°45'S, 150°32'E, vine scrub, 440m, PF9012, 27 Sept.-15 Dec. 1999, DC (QM S55218); 2♂, Mt Gavial, 450m, open forest; PF7488, 18 Dec. 98-14 Mar. 1999, DC (QM S55224); ♀, Mt Gavial, 320m, vine forest, PF7489, 17 Dec. 98-14 Mar. 1999, DC (QM S55223); ♀, Mt Gavial, 400m, open forest, PF7687, 14 Mar.-28 June 1999, DC (QM S55222); 4♂, ♀, Nipping Gully, site 1, 25°41'S, 151°26'E, 200m, rainforest, PF7397, 9 Oct.-18 Dec. 1998, GBM, C. Gough (QM S55225); ♂, Nipping Gully, site 5, 200m, rainforest, PF7503, 9 Oct.-18 Dec. 1998, GBM, C. Gough (QM S55230); ♂, Nipping Gully, site 5, 300m, rainforest, intercept trap 7705, 26 Jan.-2 June 1999, GBM, GT (QM S55229); ♂, Wetheron, 25°34'S, 151°41'E, 150m, vine scrub, PF7509, 10 Oct.-19 Dec. 1998, GBM, C. Gough (QM S55228); ♂, East Woodmillar, 25°41'S, 151°36'E, 250m, vine scrub, intereept trap, GBM, C. Gough (QM S55231); ♂, ♀, Yeppoon, Meikleville Hill, 23°06'S, 150°43'E, vine thicket, PF, 18 July-23 Oct. 1990, DW, RJR, K. Williams (QM S55279); ♂, same locality and collectors, PF, 21 April-18 July 1990 (QM S34444); 3♂, ♀, same data (QM S34448); 3♀, Olsens Caverns, 23°10'S, 150°28'E, open forest, PF, 21 Apr.-18 July 1990, DW, RJR (QM S40767); ♀, Wonga Hills, 26°03'S, 150°49'E, site 4, 470m, brigalow, PF10249, 10 Oct.-11 Dec. 2002, GBM, DC (QM S55288). OTHER

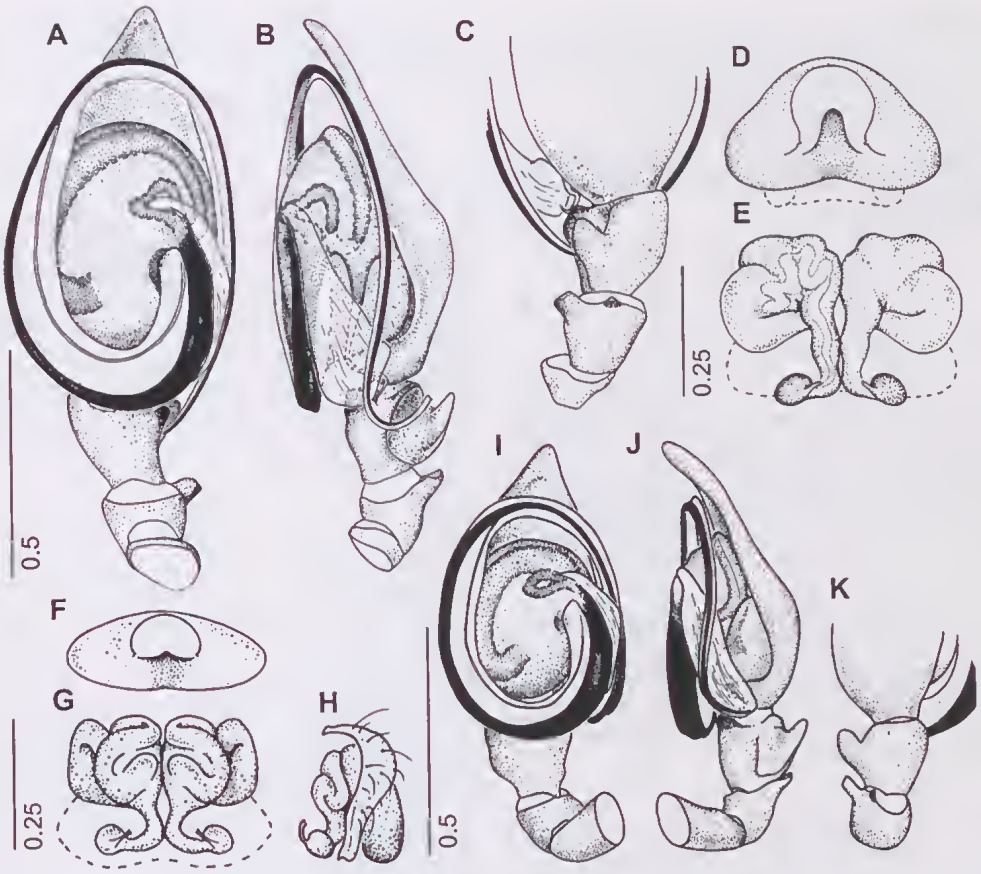

FIG. 5. A-K, *Barahna* spp. nov. A-E, *B. taroom*; A-C, ♂ palp (ventral, retrolateral, dorsal); D,E, ♀ epigynum (ventral, dorsal cleared); F-K, *B. scoria*; F-H, ♀ epigynum (ventral, dorsal cleared, lateral); I-K, ♂ palp (ventral, retrolateral, dorsal).

MATERIAL: 4♂, 2♀, Lower Dry Ck, Kroombit Tops, 45km SSW Calliope, 24°23'S, 150°56'E, 720m, microphyll rainforest, PF, site 10, 13-18 Dec. 1983, GBM, VED, J. Gallon, GT (QM S55242); 5♂, 2♀, same locality and collectors, 700m, PF, site 9, 11-18 Dec. 1983 (QM S45685); 3♀, Calliope Ra., Kroombit Tops, 24°22'S, 151°00'E, 880m, open forest, site 13, 12-18 Dec. 1983, GBM, VED, J. Gallon, GT (QM S55244); 2♂, The Caves, 23°11'S,150°28'E, open forest, PF, 21 Apr.-18 July 1990, RJR, DW (QM S40757); ♀, same locality, PF, 21 Mar. 1991, RJR, DW, K. Williams (QM S19579).

DIAGNOSIS. Embolus arises antero-retrolaterally, unlike *B. yeppoon*, which has posterior origin, distally it is gently curved (Fig. 5B), unlike *B.booloumba* which is curled. ♂ palpal patellal apophysis is truncated (Fig. 5C.), unlike the other species. Basal sclerotisation of epigynal atrium is rounded anteriorly and longer than *B. yeppoon*, not pointed like *B. booloumba*; dorsal foveal protuberances reduced.

DESCRIPTION. *Male.* CL 2.2, AL 2.2. Ratio of eyes AME: ALE: PME: PLE is 6:8:9:10. Legs 4=123. I, 9.8; II, 8.0; III, 7.2; IV, 9.8. Notation of spines differs from *B. booloumba*: Femora: II, P011, R011. Tibia: III, V221, R011; IV, D001, V111, R111.

♂ palp (Fig. 5A-C). Embolus arising antero-retrolaterally; membraneous conductor broadening distally, tegular apophysis obscured by conductor. RTA digitiform; ventro-retrolateral apophysis blunt, sclerotised, inturned. Patellal apophysis short, truncate.

Other males were smaller, ranging from 3.2-3.8 in length.

Female. CL 1.5, AL 1.7. Legs 4123. I, 4.9; II, 3.9; III, 3.6; IV, 5.0. Notation of spines differs from *B. booloumba*. Femora: I, D100; III, D001; IV, D100. Tibiae: P001, V010; III, P101, V011, R101; IV, P101, V011, R101. Epigynum (Fig.

5D,E). Basal sclerotisation of atrium is long and rounded anteriorly. Insemination ducts and spermathecae similar to *B booloumba*.

Females ranged in size from 3.2-3.6.

DISTRIBUTION. *B. taroom* (Fig. 8C) has been collected from mid-eastern to southeastern Queensland.

Barahna scoria sp. nov.
(Figs 5F-K, 8C)

ETYMOLOGY. From the type locality Mt Scoria.

MATERIAL. HOLOTYPE. ♂, Mt Scoria, southeastern Queensland, 24°32'S, 150°36'E, 200m, vine scrub, PF 9468, 29 June-21 Oct. 2000, DC, J. Wright, E. Vanderduys (QM S55212), PARATYPES. 2♀, same locality as holotype, PF 9980, 20 Dec. 2000-23 Mar. 2001, DC, GBM (QM S55214); ♂, same data (QM S55213); 3♂, same locality, PF9452, 28 Mar.-29 June 2000, DC (QM S55216).

DIAGNOSIS. Embolus arises antero-retrolaterally, encircles tegulum and is gently curved distally like *B. taroom* and unlike other species. The sclerotised atrial base is low with a small pointed apex unlike *B. taroom* where the apex is thin and rounded.

DESCRIPTION. *Male*. CL 1.3, AL 1.3. Ratio of AME: ALE: PME: PLE is 5:8:7:8. Legs 4123. I, 5.0; II, 4.0; III, 3.6; IV, 5.2. Notation of spines. Femora: I, D101, P001; II, D100, P001, R001; III, D100, P001, R001; IV, D100, P001, R001. Patellae: I, D001; II, D001; III, D001; IV, D001. Tibiae. 1, P011, V121, R001; II, P011, V112, R011; III, D001, P011, V012, R011; IV, D001, P011, V112, R011. Metatarsi spined with whorl of 4-5 spines distally.

♂ palp (Fig. 51-K). Embolus emerging antero-retrolaterally from loop of sperm duct; slightly curved distally. Ventro-retrolateral tibial apophysis blunt and sclerotised, RTA short, digitiform. Patellal apophysis short, diagonally truncated.

Other males ranged from 2.5-2.9.

Female. CL 1.3, AL 1.5. Legs 4123. I, 4.3; II, 3.5; III, 3.2; IV, 4.6. Notation of spines. Femora: I, P001; II, D100; III, D100; IV, D100, R001. Tibiae: I, V020; II, V010; III, P011, R011; IV, D001, P001, R001. Metatarsi spined with whorl of 4-5 spines distally. Epigynum (Fig. 5F-H) sclerotised base of atrium low with small pointed apex.

The other female was 2.7 in length.

DISTRIBUTION. *B. scoria* (Fig. 8C) has been collected from only one locality, Mt Scoria.

Barahna toonumbar sp. nov.
(Figs 6A-E, 8B)

ETYMOLOGY. From the type locality, Toonumbar SF.

MATERIAL. HOLOTYPE. ♂, Toonumbar SF via Grevillea, northern New South Wales, 28°28'S, 152°43'E, PF 23, 31 Mar.-2 Aug. 1975, GBM, SRM (QM S55259). PARATYPES. New SouthWales: ♂, same data (QM S55260); ♂, ♀, Border Ranges NP, Tweed Range Rd, 28°25'S, 153°02'E, 470m, 4 Feb.-9 Apr. 1993, M. Gray, G Cassis (AM KS35945); ♀, same data (AM KS35950); 3♀, Whian Whian SF, Running Rd, 28°36'S, 153°21'E, 250m, PF, 4 Feb.-9 Apr. 1993, MRG, G Cassis (AM KS35917); 2♀, Whian Whian SF, Mackays Rd, 420m, PF, MRG, G Cassis (AM KS35918).

DIAGNOSIS. Embolus shorter than that of previously described species; it arises postero-prolaterally ending mid-retrolaterally. Sclerotisation of base of epigynal atrium differs from previously described species; it is squarish and flat-topped.

DESCRIPTION. *Male*. CL 1.5, AL 1.4. Ratio of AME: ALE: PME: PLE is 6:9:8:8. Legs 4123. I, 4.3; II, 3.6; III, 3.3; IV, 4.9. Notation of spines. Femora: I, D101, P001; II. D011, P001, R001; III, D110, P001, R001; IV, D100, P001, R001. Patellae: III, D001; IV, D001. Tibiae: I, D001, P011, R011; II, D001, P101, V111, R101; III, D001, P101, V002, R101; IV, D101, P101, V112, R011. Metatarsi spined with whorl of 4-5 spines.

♂ palp (Fig. 6A-C). Embolus emerges postero-prolaterally; it describes about three-quarters of a circle around the tegulum to rest on the membraneous conductor; tegular apophysis absent. The ventro-retrolateral apophysis inturns acutely to a point. RTA pointed. Patellal apophysis short.

Other two males 2.5 and 2.8 in length.

Female. CL 1.1, AL 1.5. Legs 4123. I, 3.4; II, 2.9; III, 2.6; IV, 3.6. Notation of spines. Femora: I, D100, P001; II, D100; III, D100, R001; IV, D100, R001. Patellae: II, D001; III, D001; IV, D001. Tibiae: I, V001; II, P001, V001, R001; III, D001, P101, V011, R101; IV, D100, P100, V001, R001. Metatarsi spined with whorl of 4-5 spines distally. Epigynum (Fig. 6D,E) basal sclerotised area flat-topped.

Other females ranged from 2.3-3.5.

DISTRIBUTION. *B. toonumbar* (Fig. 8B) has been collected from the Border Range area of northern New South Wales.

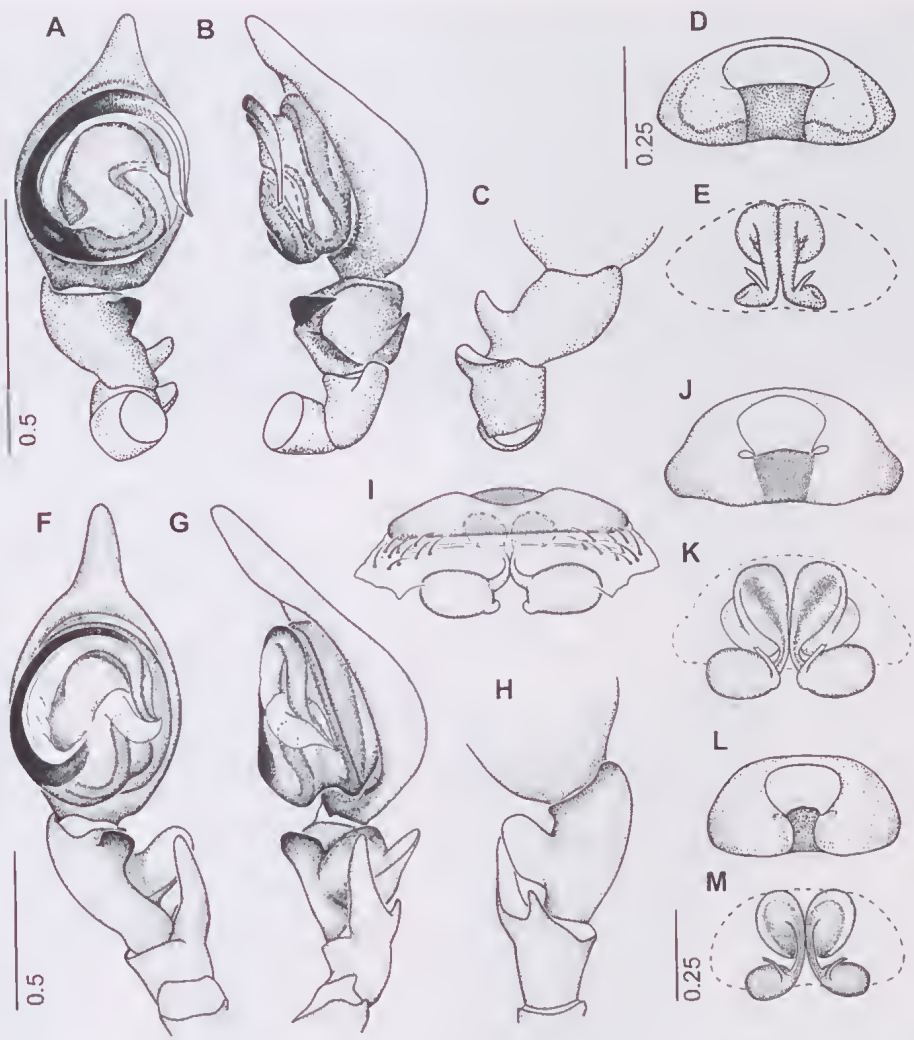

FIG. 6. A-L, *Barahna* spp. nov. A-E, *B. toonumbar*; A-C, ♂ palp (ventral, retrolateral, dorsal); D,E, ♀ epigynum (ventral, dorsal cleared); F-K, *B. myall*; F-H, ♂ palp (ventral, retrolateral, dorsal); I-K, ♀ epigynum (posterior, ventral, dorsal cleared); L,M, *Barahna glenelg*, ♀ epigynum (ventral, dorsal cleared).

Barahna myall sp. nov.
(Figs 6F-K, 7B,C, 8B)

ETYMOLOGY. From type locality, Myall Lakes NP.

MATERIAL. HOLOTYPE. ♂, Myall Lakes NP, New South Wales, 32°38'S, 152°12'E, PF, 10 Oct. 1997, L. Wilkie (AM KS71037). PARATYPES. N.S.W: 2♂, 2♀, Smiths Lake, Myall Lakes, 32°23'S, 152°30'E, dry sclerophyll, 8 May 1974, L. Blyton (AM KS34835); ♀ (tracheal tubes dissected) same data (AM KS34835); ♂, Myall Lakes, same data as holotype (AM KS71036); ♀, 1 June 1997 (AM KS71035); 3♂, ♀, same data as holotype (AM KS62448); ♀ (AM KS62449); ♀, with egg sac, Upper Allyn, 32°22'S, 151°32'E, MRG (AM KS34837); ♀, Gloucester, 56km W on Barrington Tops Forest Rd, 32°01'S, 151°22'E, 17 Mar. 1982, MRG, H. Parnaby (AM KS8829). ♂, Kerewong SF nr Lome, 31°36'S, 152°34'E, PF coll. 15 July 1979, D. Milledge (AM KS5404); ♀, same data (AM KS71034). ♂, Lome SF, 31°35'S, 152°57'E, PF, coll. 4 Nov. 1979, D. Milledge (AM KS5599); ♂, same data (AM KS5641); 2♀, same data (AM KS5667); 2♂, same location, coll. 30 July 1979 (AM KS16214); ♀, same data (AM KS16219); ♀, Dorrigo NP, Dorrigo-Bellingen Rd, 30°24'S, 152°45'E, PF, 18 Feb. 1993, MRG, G. Cassis (AM KS35767). ♀, Kuring-gai NP, Bobbin Head (W side), 33°39'S, 151°09'E, 10 Apr. 1974, MRG (AM KS34832); ♀, same locality, 10 May 1974, MRG (AM KS34833); ♀, same locality, 2 Nov. 1993, MRG (AM KS34834); 2♂, ♀, juvs. Maria SF nr Kempsey, 31°11'S, 152°50'E, in logs,

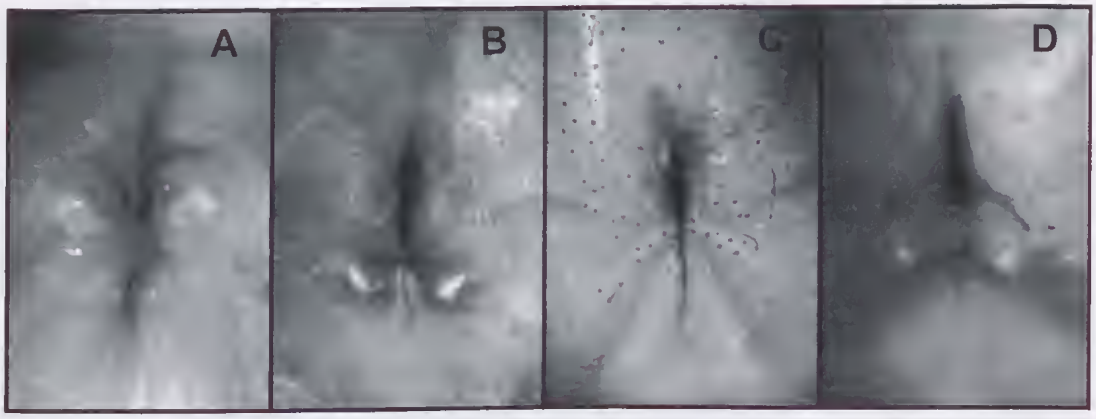

FIG. 7. A-D, *Barahna* spp. nov. foveal areas. A, ♀ *B. booloumba*; B, ♀ *B. myall*; C, ♂ *B. myall*; D, ♀ *B. glenelg*.

Eucalyptus gummifera (Bloodwood forest), 23 Apr. 1974, MRG (AM KS34836); ♀, Bulls Ground SF, nr Wauchope, 31°35'S, 152°41'E, PF, 10 Feb. 1991, A. York, NSW Forestry (AM KS43484); ♂, Kiwarrak SF, nr Taree, 31°58'S, 152°26'E, PF coll. 28 Sept. 1979, W.C. King (AM KS3943). 2♀, Glen Dhu Cave Timor, 31°34'S, 151°27'E, cave, 25 May 1995, S. Eberhard (AM KS57011).

DIAGNOSIS. Larger than other species, seldom less than 5.0 in length. Embolus arises postero-prolaterally and terminates mid-retrolaterally as in *B. toonumbar* and unlike other species. Patellal apophysis very long and bifid unlike *B. toonumbar*. Selerotised base of atrium is flat and square like *B. toonumbar*. Spermatheeae larger than other species.

DESCRIPTION. *Male*. CL 3.0 AL 2.4. Ratio of AME: ALE: PME: PLE is 10:13:12:13. Legs 4123. I, 10.5; II, 8.8; III, 8.0; IV 11.0. Notation of spines. Femora: I, D101, P002, R001; II, D101, P011, R011; III, D111, P011, R011; IV, D110, P001. Patellae: II, D001; III, D001. Tibiae: I, P110, V202, R011; II, P011, V222, R011; III, D001, P011, V222, R011; IV, D100, P101, V222, R011. Metatarsi spined with distal whorl of 5 spines.

♂ palp (Fig. 6F-H). Embolus arises posteriorly deseribing about three quarters of a eirele round the tegulum to rest on membraneous eonduetor. Tegular apophysis absent. Short, blunt ventro-RTA, digitform RTA. Bifid patellal apophysis, longer than RTA.

Other males ranged from 3.6-5.6.

Female. CL 2.4 AL 2.8. Ratio of AME: ALE: PME: PLE is 9:13:11:14. Legs 4123. I, 7.9; II, 6.4; III, 5.7; IV, 8.5. Notation of spines. Femora: I, D101, P002, R001; II, D101, P011, R011; III, D111, P011, R011; IV, D110, P001. Patellae. II, D001; III, D001. Tibiae: I, P110, V202, R011; II, P011, V222, R011; III, D001, P011, V222, R011; IV, D100, P101, V222, R011. Metatarsi spined with whorl of 5 spines distally.

The foveal area is almost flat and the associated pale areas dorsal rather posterior (Fig.7B); further investigation did not show any pores. The male lacks the swellings and pale areas (Fig. 7C).

Epigynum (Fig. 6I-K). Basal selerotised area of atrium flat-square; spermatheeae large. Four simple traeheal tubes in abdomen, medians longer than laterals (disseetion eourtesy of M.R.Gray).

Other females ranged from 5.2-6.5.

DISTRIBUTION. *B. myall* (Fig.8B) was eolleeted from eastern New South Wales. Females from Kuring-gai NP near Sydney whieh are plaeed in this speeies need further eonfirmation when males are available.

Barahna glenelg sp. nov.
(Figs 6L,M, 7D, 8D)

ETYMOLOGY. From the type locality, Glenelg R.

MATERIAL. HOLOTYPE. ♀, Glenelg R, Dartmoor, Vietoria, 37°55'S, 141°16'E, under logs at base of limestone outerop, 25 Mar. 1974, MRG (AM KS034839).

DIAGNOSIS. Foveal protuberanees broader than other speeies. Basal selerite flat-topped like *B. toonumbar* and *myall* but differing from these in being longer than wide.

DESCRIPTION. *Female*. CL 2.5, AL 2.9. Ratio of AME: ALE: PME: PLE is 8:10:9:9. Coloration and pattern similar to other speeies. Foveal protuberanees oeeupying a wider area separating foveal groove (Fig. 7D). Legs 4123. I, 7.2; II, 6.5;

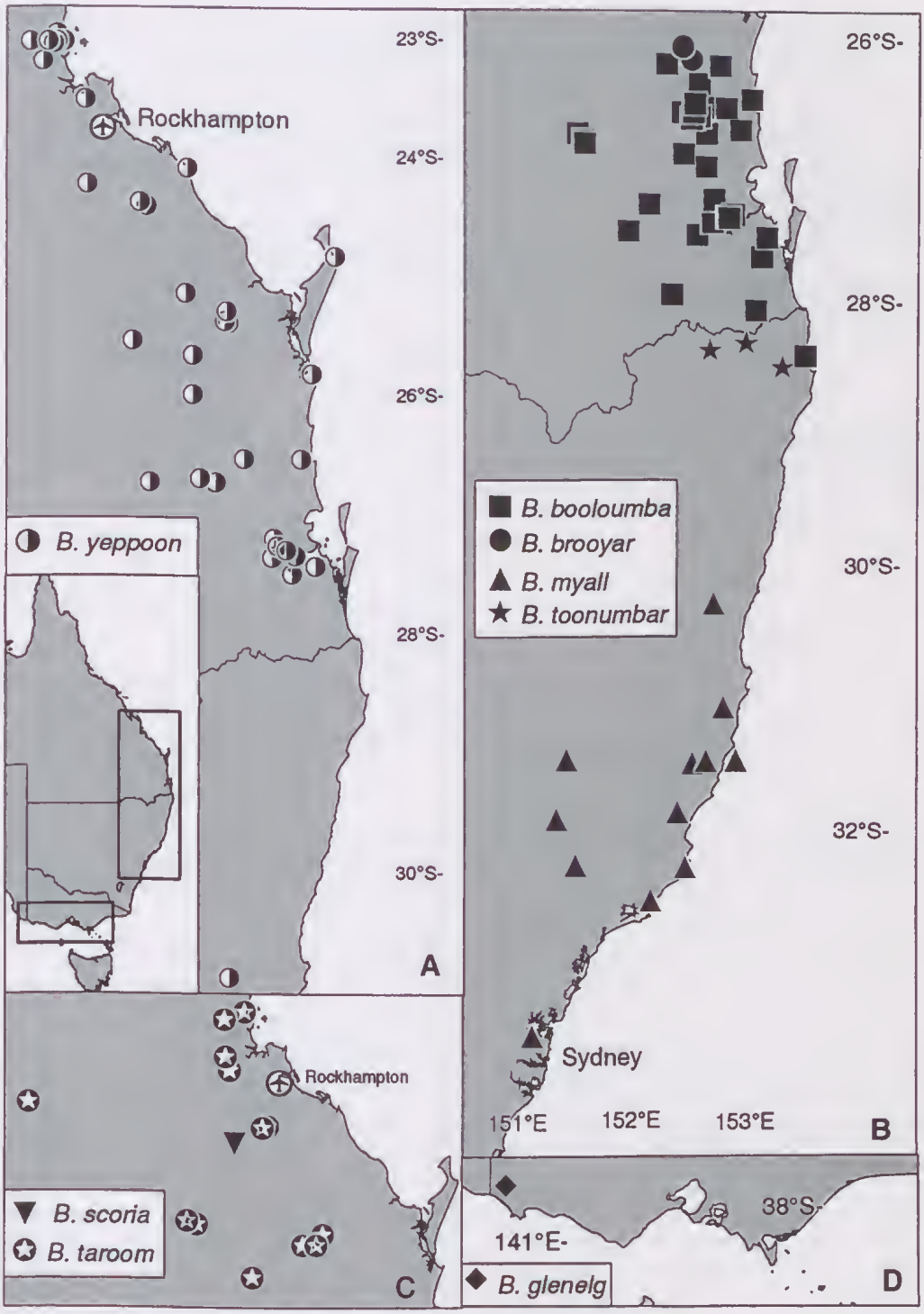

FIG. 8. A-D, distribution maps of *Barahna* spp. nov. A, *B. yeppoon*; B, *B. booloumba*, *B. brooyar*, *B. myall*, *B. toonumbar*; C, *B. scoria*, *B. taroom*; D, *B. glenelg*.

III, 5.9; IV, 7.8. Notation of spines. Femora: I, D101, P002, R001; II, D101, P001, R001; III, D111, P011, R001; IV, D101, P001, R001. Tibiae: I, P011, V221, R000; II, P011, V202, R011; III, D001, P101, V122, R101; IV, D001, P101, V112, R101. Metatarsi spined with distal whorl of 4-5 spines.

Epigynum (Fig. 6L,M). Basal sclerite of atrium longer than wide, flat-topped.

The male is unknown.

DISTRIBUTION. One female *B. glenelg* (Fig. 8D) has been collected from Glenelg R., near Dartmoor, Victoria.

ACKNOWLEDGEMENTS

I am indebted to curators and collection managers of the Australian, West Australian and South Australian Museums for loans of material for this study, and especially to colleague Dr G.B. Monteith and his co-workers for collections from mid-eastern and southeastern Queensland and northern New South Wales. I thank the Council of the Australian Biological Resources Study for its funding of rainforest surveys during which some of these spiders were collected and for financial support for illustrators Catherine Harvey and Dr Christine Lambkin and SEM technician Kylie Stumkat. I am indebted to Dr Robert Raven for construction of the distributional maps.

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TANGANA, A NEW SPIDER GENUS FROM AUSTRALIA (AMAUROBIOIDEA: AMPHINECTIDAE: TASMARUBRIINAE)

VALERIE TODD DAVIES

Davies, V.T. 2003 06 30: *Tangana*, a new spider genus from Australia (Amaurobioidea: Amphinectidae: Tasmarubriinae). *Memoirs of the Queensland Museum* **49**(1): 251-259. Brisbane. ISSN 0079-8835.

Six species of *Tangana* gen. nov. are described. They are *T. greeni* (type species), *T. collina*, *T. mcpartlan*, *T. acuta* and *T. clarkei* all from Tasmania, the island state off the southeast coast of Australia and *T. harveyi* from Victoria, mainland Australia. They are placed with *Tasmarubrius* and *Tasmabrochus* in the subfamily Tasmarubriinae. ❐ *Amaurobioidea, Amphinectidae, Tangana, new genus, Australia.*

Valerie Todd Davies, Queensland Museum, PO Box 3300 South Brisbane 4101, Australia; *9 May 2003.*

The Tasmarubriinae was diagnosed and described by Davies (2002). Like the other genera, *Tangana* spp. are large (8.0 or longer) cribellates found in small retreats under logs or rocks. Some species were sympatric, even found in the same pitfall sample. The only modification from the description (loc. cit.) concerns the curvature of the eye rows — viewed from above the anterior row is slightly recurved, the posterior row straight to slightly procurved (Fig.1D). It is thought that the broad embolus conveys not only the sperm duct but also the duct carrying the acellular glandular secretion that plugs the female gonopores (Suhm, Thaler & Alberti, 1996).

MATERIAL AND METHODS

All but one of the following taxa were collected from sites in Tasmania, the exception being a single female from Victoria. Much of the material, comprising about 50 vials from Maggs Mt, NW Tasmania was collected by R.H. Green. To avoid repetition in listing these, after the first record the collector's name and locality name are omitted. Pitfalls (PF) were the main trapping method, with some hand-collecting. Notation of spines follows Platnick & Shadab (1975). The left male palp is described and illustrated. Measurements are in millimetres. The epigyna vary little between species thus there is an emphasis on male characters and males only are used in the key.

ABBREVIATIONS. Museums: AM, Australian Museum, Sydney; QM, Queensland Museum, Brisbane; QVM, Queen Victoria Museum, Launceston; SAM, South Australian Museum, Adelaide; TM, Tasmanian Museum and Art Gallery, Hobart; WAM, West Australian Museum, Perth. Morphology: The usual abbreviations are used for body measurements and eyes. MA, median apophysis; RTA, retrolateral tibial apophysis. Other abbreviations on illustrations are explained in the text or in the legends.

SYSTEMATICS

Tangana gen. nov.

TYPE SPECIES. *T. greeni* sp. nov.

ETYMOLOGY. From the Aboriginal 'tangana', meaning spider in the Tasmanian language.

DIAGNOSIS. Males differ from other tasmarubriines (*Tasmarubrius* and *Tasmabrochus*) in lacking a large fixed prolateral tegular apophysis and in having a terminally branched median apophysis. Lateral teeth are present on epigynum. Spines on both male and female tarsi III and IV, smaller than those on other leg segments and not present in other tasmarubriines.

DESCRIPTION. Large, 3-clawed cribellates with genicular chelicerae, 2 retromarginal and 2 promarginal cheliceral teeth with an intermediate row of tiny thin denticles. Preening combs on distal metatarsi I (a few tines), II, III and IV. Short thick embolus, small membraneous conductor and movable median apophysis. A small tegular bulge may be present between embolic base and median apophysis. Small proximal paracymbium usually present. Palpal tibia with long ridge-like distal retroventral apophysis and an excavated retrolateral apophysis with two or more processes. Epigynum with lateral teeth. Gonopores often blocked with acellular material, insemination ducts heavily sclerotised, large spermathecae.

KEY TO MALE *TANGANA*. SPP.

1. Small membraneous tegular apophysis present (Fig. 2C) . . . . . *greeni*
   Small membraneous tegular apophysis absent 2
2. Median apophysis trifurcate (with small ventral branch) . . . . . *acuta*
   Median apophysis bifurcate (prolateral and dorsal branches only). 3
3. Retrodorsal branch of RTA rounded (Fig. 3C) . . *collina*
   Retrodorsal branch of RTA pointed. 4
4. Retrolateral branch of RTA with proximal spur (Fig. 4C) . . . . . *mcpartlan*
   Retrolateral branch of RTA without proximal spur . . . . . *clarkei*

Male of *T. harveyi* is unknown.

Tangana greeni sp. nov.
(Figs 1, 2, 6A; Table 1)

ETYMOLOGY. In honour of Robert H. Green, collector of many Tasmanian spiders.

MATERIAL. HOLOTYPE. ♂, Maggs Mt, NW Tasmania, 41°45'S, 146°12'E, PF, 13 June-19 Sept. 1979, R.H.Green (QVM 13:39937). PARATYPES: Tasmania. 4♀, same data as holotype (QVM 13:39938);17♂, same data (QVM 13:39939); ♂ (QVM 13:39940); ♂,♀, same data, 15 Oct. 1979 (QVM 13:7076); ♀, 2♂, juvs, 17 Oct. 1979 (QVM 13:7075); 2♂, 10 Oct. 1979 (QVM 13:7072); ♂, 23 Sept. 1981 (QVM 13:42035); 8♂, ex *Poa* tussock, dry sclerophyll, 14 Oct. 1980 (QVM 13:42081); 2♂, 17 Oct.1979 (QVM 13:42133); 2♂, ♀, (QVM 13:42137); ♂, 4♀, 14 Nov. 1984 (QVM 13:42238); ♀, 500m from camp, dry sclerophyll, 19 Nov. 1980 (QVM 13:42274); ♂, 26 Nov. 1987 (QVM 13:42427); 2♀, W field station, dry sclerophyll, PF, 8 Oct.-6 Nov. 1979 (QVM 13:42522); ♀, Arm R Camp, wattle, 5 Feb.1980 (QVM 13:42719); ♀, 26 Nov. 1987 (QVM 13:42723); ♂, 23 Sept. 1985 (QVM 13:42838); 8♂, 26 Nov. 1987 (QVM 13:42842); ♂, ♀, wet sclerophyll, 16 Oct. 1979, Forestry (QVM 13:43635); 14♀, wet sclerophyll, 800m, 14 Oct. 1980 (QVM 13:43638); 42♂, same data (QVM 13:43640); 2♂, 26 Sept. 1989 (QVM 13:43641); 2♂, 7 Sept.1987, Forestry (QVM 13:43642); 3♂, 500m, 14 Oct. 1980 (QVM 13:43643); ♂, 25 Nov. 1986 (QVM 13:43650); 4♂, ♀, 13 Oct. 1982 (QVM 13:43634); ♀, 25 Nov. 1986 (QVM 13:43652); ♀, 13 Oct. 1982 (QVM 13:43715); 7♂, 10 Oct. 1983 (QVM 13:42600); ♂, Cradle Mt, Pencil Pine Ck, 41°38'S,145°54', 16 - 24 April 1980, R.H.Green (QVM 13:43655); ♀, Mt Field, 42°41'S, 146°43'E, 200m, under log, 20 May 1996, L.J. Boutin (TM J3312); ♀, ♂, juv., 8km SW Waratah, NW Tasmania, 41°29'S, 145°27'E, 690m, PF, 17 Aug.-3 Dec. 1990, R. Mesibov (QVM 13:23308); ♀, same data, 680m (QVM 13:23315); ♂, 670m (QVM 13:23316); ♂, (QVM 13:23322); ♀, (QVM 13:23323); ♀, Mt Barrow, NE Tasmania, 41°23'S, 147°25'E, 25 Apr. 1971, R.H.Green (QVM 13:42359); ♂, same data (QVM 13:42360); ♂, (QVM 13:42364); 2♂, nr Pioneer, NE Tasmania, 41°03'S,148°01'E, Forestry (TM J3313); ♀, NE Tasmania, *Nothofagus* forest nr Weldborough, 41°12'S, 147°54'E, Aug. 1993, P. Cranston, J. Trueman (QM S55289): 2♂, 8km SW Waratah, NW Tasmania, 41°29'S, 145°27'E, 680m, 20 Sept. 1990, R. Mesibov (QVM 13:43654); ♂ Black Bog Ck, 870m, 8 July 1997, R. Mesibov (QVM 13:43656); ♂, same data, 830m (QVM 13:43657); ♂, Central Plateau, Butlers Rd nr Tarraleah, 700m, 20 Oct. 1992, R. Brereton (QVM 13:43658); ♂, same data, 18 Aug. 1992 (QVM 13:43659); ♂, Central Plateau, Homes Dam nr Tarraleah, 750m, 1992 (QVM 13:43694). OTHER MATERIAL: ♂, Maatsuyker I., S Tasmania, 43°39'S, 146°16'E, Site 3, 10-22 Dec. 1996, S.J. Cronin (QVM 13;23836).

DIAGNOSIS. Median apophysis trifurcate distally with spur-like prolateral,long dorsal (largely obscured by trunk) and very short retrolateral branches. Small membraneous tegular projection (apophysis) at retrolateral base of embolus. Palpal tibia with long blunt ridge-like distal retroventral apophysis; excavated retrolateral apophysis with long digitiform retrolateral and curved retrodorsal apophyses. The latter with a flat rounded centro-retrolateral projection (Figs 1C, 2D) connected by a low ridge to the retrodorsal apophysis.

DESCRIPTION. *Male*. CL 6.1, CW 4.8, AL 5.8, AW 3.5. Light brown cephalothorax, almost glabrous. Dorsal abdomen pale with six dark chevrons with pairs of light spots between them. Pale venter. From above posterior row of eyes straight, anterior row slightly recurved. AME smallest Ratio of AME: ALE: PME: PLE is 7:12:10:11. Chelicerae slightly geniculate, two retromarginal and two promarginal teeth, intermediate row of tiny thin denticles (Fig. 2A,B). Labium as wide as long. Sternum a little longer than wide, 1:0.9. Legs 4123 (Table 1). Notation of spines. Femora: I, D111, P012, R111; II, D111, P111, R011; III, D111, P101, R011; IV, D110, P010, R001. Tibiae: I, P111, V221, R001; II, P111, V222, R001; III, D011, P111, V222, R111; IV, D001, P111, V222, R111. Metatarsi: I, P001, V222, R001; II, D010, P111, V221, R011; III, D101, P111, V221, R111; IV, D110, P112, V221, R112. Tarsi: III, P011, R011; IV, P011, R010.

TABLE 1: *T. greeni* ♂(♀) leg lengths.

	Leg I	Leg II	Leg III	Leg IV
Femur	6.3 (5.4)	6.0 (4.7)	5.6 (4.5)	6.4 (5.8)
Patella & Tibia	8.1 (6.8)	7.2 (6.2)	6.7 (5.4)	8.1 (6.8)
Metatarsus	5.8 (4.4)	5.6 (4.3)	5.8 (4.2)	8.2 (6.1)
Tarsus	3.9 (2.8)	3.6 (2.6)	3.1 (2.1)	3.5 (2.6)
Total	24.1 (19.4)	22.4 (17.8)	21.2 (16.2)	26.2 (21.3)

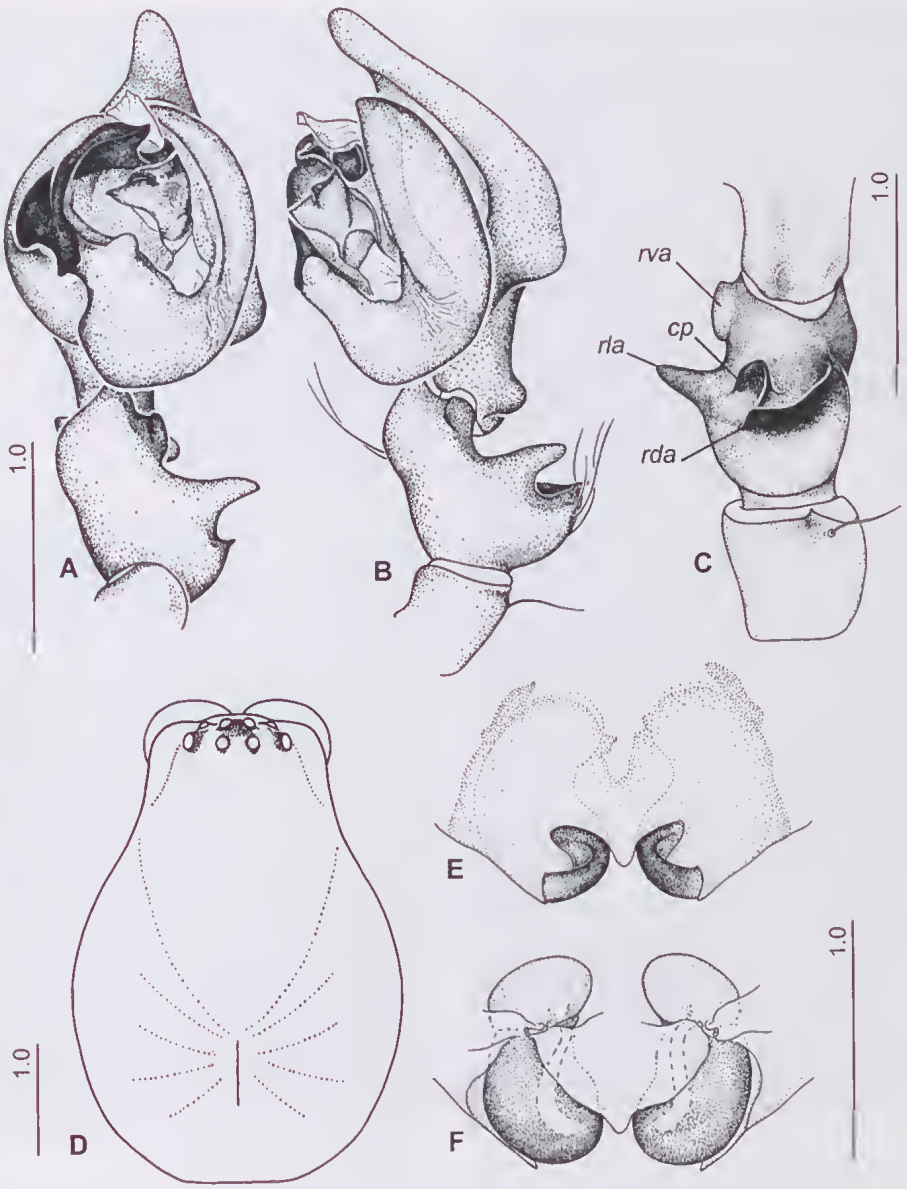

FIG. 1. A-F, *Tangana greeni* sp. nov. A-C, ♂ palp (ventral, retrolateral, dorsal); D, dorsal carapace; E-F, epigynum (ventral, dorsal). cp = central process of RTA; rda = retrodorsal apophysis; rla = retrolateral apophysis; rva = retroventral apophysis of tibia.

♂ palp (Figs 1A-C, 2C,D). Cymbium with bulge on retrolateral edge, narrow neck region with small rounded proximal projection (paracymbium). Thick embolus, small membraneous conductor, short terminally trifurcate median apophysis and small blunt membraneous tegular projection prolateral to it. Tibia with distal retroventral apophysis and excavated retrolateral apophysis consisting of digitiform retrolateral process and curved retrodorsal apophysis. The latter with a rounded central process connected by a low ridge to the blunt retrodorsal apophysis.

Males varied in length from 9.2 - 11.5.

Female. CL 5.8, CW 4.0, AL 5.3, AW 3.4. Similar pattern to male. Ratio of AME: ALE: PME: PLE is 7:10:9:10. Legs 4123 (Table1). Notation of

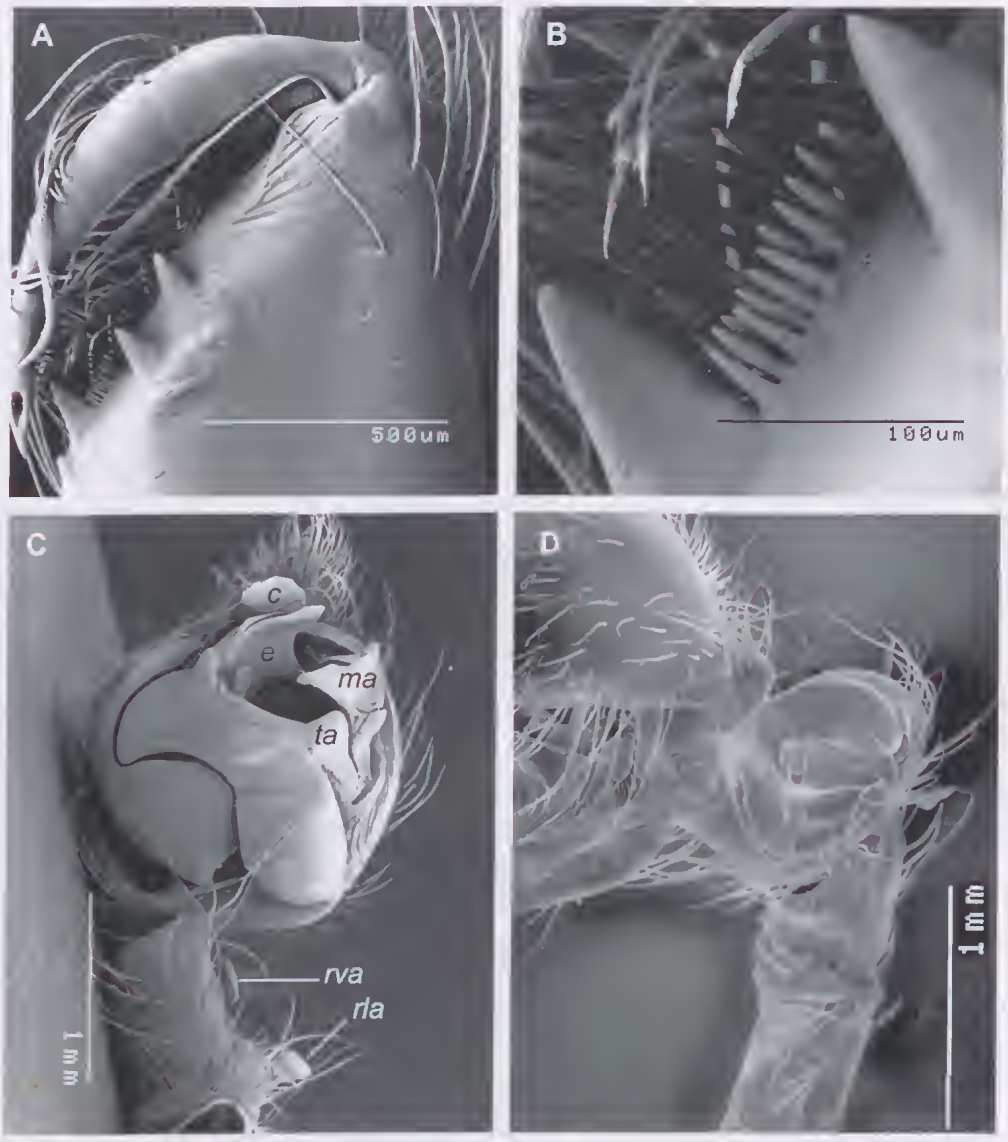

FIG. 2. A-D, *Tangana greeni* sp. nov. A,B, chelicera; C,D, ♂ palp (ventral, retrolateral). c = conductor; e = embolus; ma = median apophysis; rla = retrolateral apophysis of RTA; rva = retroventral apophysis; ta = tegular apophysis.

spines. Femora: I, D110, P011, R011; II, D111, P111, R001; III, D111, P101, R011; IV, D111, P101, R001. Tibiae: I, P111, V222; II, P011, V222; III, D101, P111, V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, P011, V221, R011; II, P111, V221, R111; III, D100, P111, V221, R111; IV, D110, P112, V221, R112.Tarsi: III, P010, R010; IV, P010, R011.

Epigynum (Fig. 1E,F) about a fifth the length of venter. Postero-lateral gonopores leading through heavily selerotised insemination duets to spermatheeae thence by fertilisation duets to uterus. Irregular shaped plugs in some gonopores.

Females varied in length from 9.0 - 14.0.

DISTRIBUTION (Fig. 6A). Found over a wide area in NW Tasmania and Central Highlands region and to a lesser extent in NE Tasmania. One male from Maatsuyker I., in the south, is not listed as a paratype.

Tangana collina sp. nov.
(Figs 3A-E,6B)

ETYMOLOGY. From Latin 'collis', high ground.

MATERIAL. HOLOTYPE. ♂, Maggs Mt, NW Tasmania. 41°45'S, 146°12'E, PF,13 June-19 Sept. 1979, R.H. Green (QVM 13:39941). PARATYPES: Tasmania. ♀, same data as holotype (QVM 13:39942); 8♂, same data (QVM 13:39943); ♂, ♀, 7 Nov. 1987 (QVM 13: 42722).; 2♂, 26 Nov. 1987 (QVM 13: 42843); 2♂, 20 Sept.1988 (QVM 13: 43636) ; ♂, 18 Sept.1984 (QVM 13: 43637); ♀, 14 Nov.1984 (QVM 13: 43644); ♀, 23 Feb.1988 (QVM 13:43645); ♀, 4 Feb.1980 (QVM 13:43647); ♀, 22 Feb. 1983 (QVM 13: 43648); 2♀, 9 Feb. 1982 (QVM 13: 43651); ♀, 11 Feb. 1987 (QVM 13: 43691); ♀, 25 Nov. 1986 (QVM 13:43692); ♂, 15 June 1984 (QVM 13: 43693); 9♂, ♀, 14 Oct.1980 (QVM 13:39944); ♂, 23 Sept.1981 (QVM 13:39945); ♂, 10 Oct. 1983 (QVM 13:39946); ♂, Maggs Mt, Arm R., Camp, wattle, 7 Sept. 1987, Forestry, (QVM 13:39947); 2♂, Cradle Mountain, Pencil Pine Creek, 41°38'S, 145°54'E, 16-24 Apr. 1980, R.H.Green (QVM 13:39948); ♀, Upper Natone Forest Reserve, 41°14'S, 145°53'E, under log, 6 June 1989, J.L. Robinson (TM J2825); ♀, along Obsidian Ck, Savage R.,W Tasmania, 41°35'S, 145°08'E, 6 Aug. 1974, R. Mesibov (TM J102).

DIAGNOSIS. A larger spider than T. *greeni*. ♂ palp with flange-shaped paracymbium (Fig. 3B). MA terminally bifurcate, lacking the retrolateral branch. Without tegular projection. Palpal tibia with ridge-like retroventral apophysis, excavated RTA with a rounded retrolateral and curved retrodorsal branch, lacking the central process. Gonopores slit-like.

DESCRIPTION. *Male*. CL 7.3, CW 5.3, AL 6.7, AW 3.7. Similar colour and pattern to *D. greeni*. Ratio of AME; ALE: PME: PLE is 9; 12: 12: 14. Legs 4123. I, 26.3; II, 24.0; III, 22.7; IV, 29.9. Notation of spines. Femora: I, D111, P011, R011; II, D111, P111, R011; III, D111, P111, R021; IV, D111, P101, R011. Tibiae: I, P111, V222, R111; II, P111, V 222, R111; III, D111, P111, V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, P111, V221, R011; II, P011, V 221, R111; III, D110, P112, V 221, R 112; IV, D110, P112, V 221, R112. Tarsi: III, P010, R 010; IV, P001,R011.

♂ palp (Fig. 3A-C). Cymbium with bulge on retrolateral edge, narrow neck region and proximal paracymbium. Thick embolus, membraneous conductor, bifurcate MA with prolateral and dorsal branches only. Tibia with blunt retroventral apophysis, excavated RTA with rounded retrolateral and curved retrodorsal branches.

Males varied in length from 11.4 - 14.0.

Female. CL 7.9, CW 5.5, AL 8.8, AW 5.4. Ratio of AME: ALE: PME: PLE is 9:12:11:12. Legs 4123. I, 23.3; II, 20.6; III, 20.4; IV, 26.4. Notation of spines. Femora: I, D111, P001, R011; II, D111, P111, R011; III, D111, R012; IV, D111, P011, R011. Tibiae: I, P111, V 222; II, P111, V 222; III, D111, P111, V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, P011, V221, R011; II, P111, V221, R011; III, D100, P111, V221, R111; IV, D110, P112, V221, R112.Tarsi:III, P011, R011; IV, P011, R011.

Epigynum (Fig. 3D,E) about an eighth the length of venter. Slit-like gonopores.

Females ranged in length from 13.5 - 20.0.

DISTRIBUTION (Fig. 6B). Sympatric with *T. greeni* at Maggs Mt, NW Tasmania and found further west.

Tangana mcpartlan sp. nov.
(Figs 4A-E, 6B)

ETYMOLOGY. From the type locality, McPartlan Pass, SW Tasmania.

MATERIAL. HOLOTYPE: ♂, McPartlan Pass, SW Tasmania, 42°51'S,146°11'E, 200m , PF, Mar. 1999, M.Driessen (QM S55290). PARATYPES: Tasmania. ♀, same data as holotype (QM S55291); ♀, same data, 12 Mar. 1999 (QM S55292); ♂, same data, 21 Mar. 2001, (QM S55318).

DIAGNOSIS. Large spider. MA bifurcate distally with long prolateral and dorsal branches, lacking retrolateral branch. Tegular projection absent. Palpal tibia with ridge-like retroventral apophysis, excavated RTA with a rounded digitiform retrolateral branch with small proximal process (Fig. 4C); curved retrodorsal branch with flat rounded process curving to dorsal spur.

DESCRIPTION. *Male*. CL 7.1, CW 5.4, AL 6.3, AW 3.8. Red brown cephalothorax. Abdomen brown with six paired pale spots. Labium longer than wide 1: 0.7. Sternum longer than wide 1: 0.9. Ratio of AME: ALE: PME: PLE is 8:9:9:10. Legs 4123; I, 24.5; II, 22.8; III, 22.3; IV, 28.1. Notation of spines. Femora:I, DI11, P011, R022; II, D111, P112, R012; III, D111, P111, R021; IV, D111, P111, R011. Patellae: III ,D001; IV, D001. Tibiae: I, P111, V222, R111; II, P111, V222, R111. III, D111, P111,V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, D110, P112, V221, R112; II, D111, P112, V221, R112; III, D111, P111, V221, R112; IV, D110, P212, V221, R212. Tarsi: III, P010, R010; IV, P011, R011.

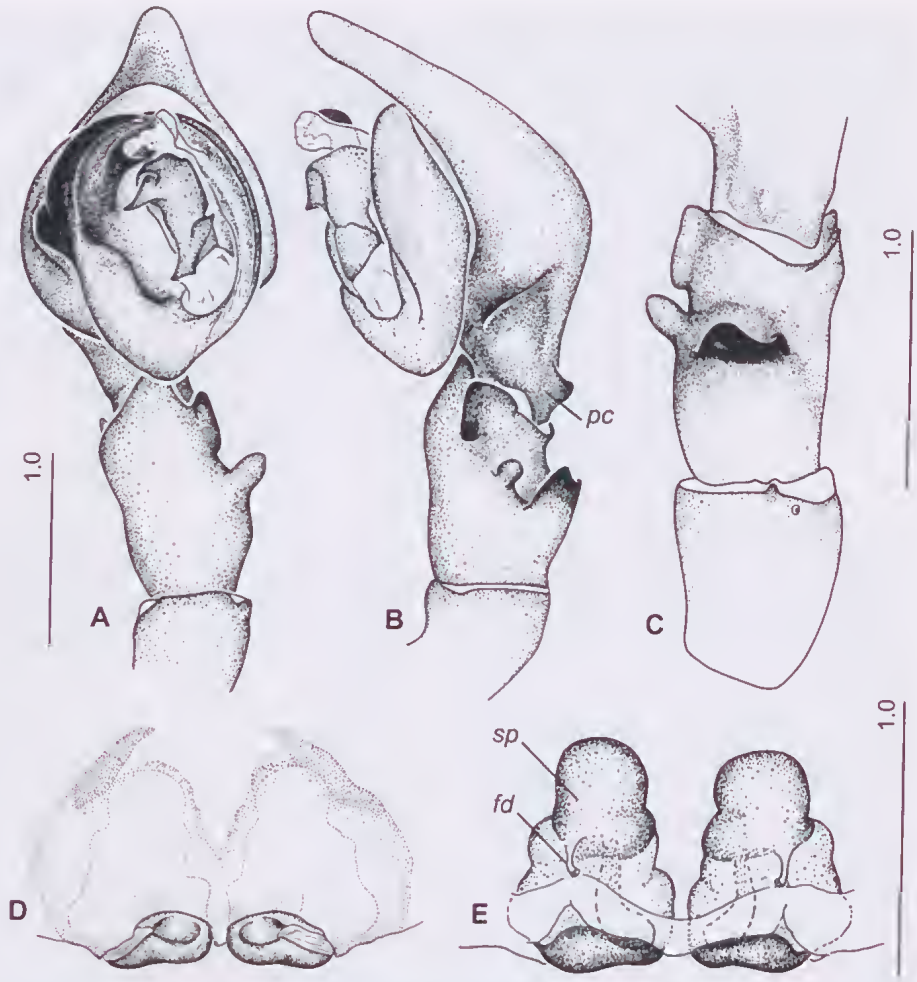

FIG. 3. A-E, *Tangana collina* sp. nov. A-C, ♂ palp (ventral, retrolateral,dorsal); D,E, epigynum (ventral, dorsal). fd = fertilisation duct; pc = paracymbium; sp = spermathecae.

♂ palp (Fig. 4A-C). Cymbium with bulge on retrolateral edge, narrow neck region with small rounded paracymbium. Thick embolus, small membraneous conductor, MA terminally bifurcate. Tibia with ridge-like retroventral apophysis, excavated RTA.

Female. CL 8.1, CW 5.4, AL 7.3, AW4.5. Coloration similar to male. Ratio of AME: ALE: PME: PLE is 7:9:10:11. Notation of spines. Femora: I, D111, P011, R011; II, D111, P111, R111; III, D111, P111, R111; IV, D111, P111, R011. Patellae: III, D001; IV, D001. Tibiae: I, P011, V222; II, P111, V222; III, D111, P111, V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, P111, V221, R001; II, P012, V221, R012; III, D100, P112, V221, R112; IV, D101, P112, V221, R112. Tarsi: III, P010, R010; IV, P010, R010.

Epigynum (Fig. 4D,E) about a sixth the length of venter. Curved, pointed lateral teeth.

Other ♀ CL 7.8, CW 5.3, AL 9.7, AW 6.3.

DISTRIBUTION (Fig. 6B). From McPartlan Pass, SW Tasmania.

Tangana acuta sp. nov.
(Figs 5A-C, 6B)

ETYMOLOGY. From the Latin 'acutus', pointed referring to the sharply pointed tip of the embolus.

MATERIAL. HOLOTYPE: ♂, nr Pioneer, NE Tasmania, 41°03'S, 148°01'E, PF, Forestry (TM J3314). PARATYPES: 2♂, same data as holotype (TM J3315).

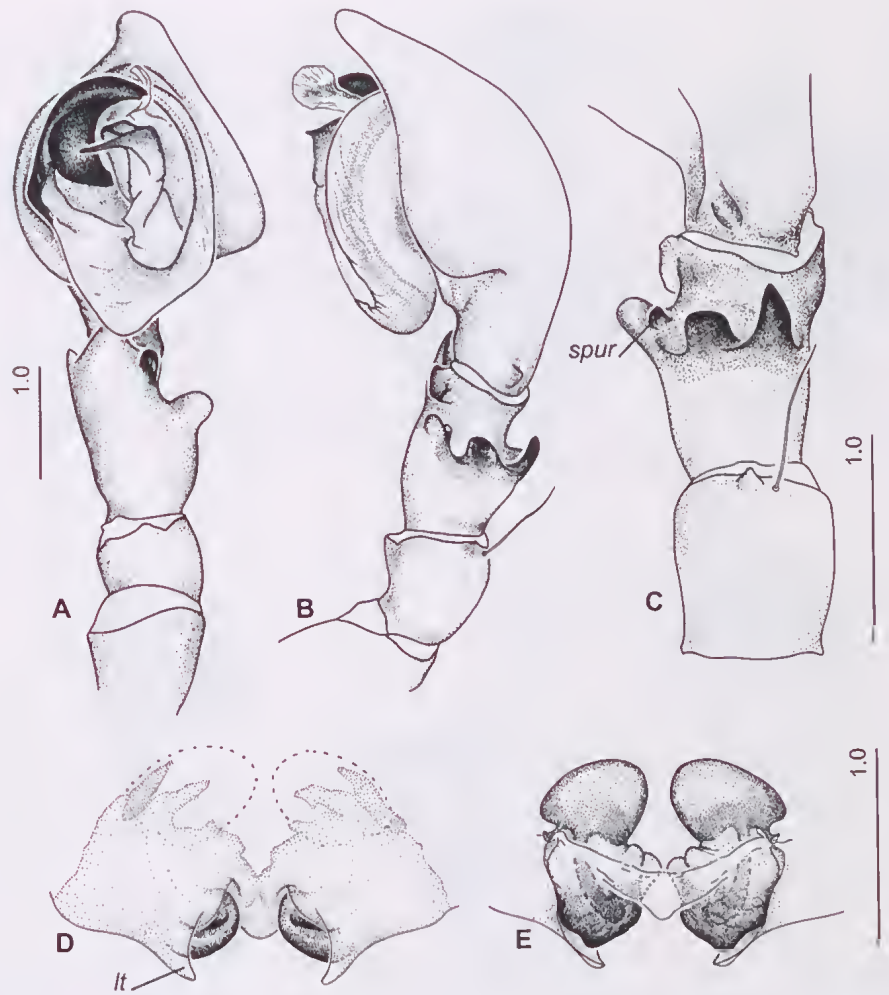

FIG. 4. A-E, *Tangana mcpartlan* sp. nov. A-C, ♂ palp (ventral, retrolateral, dorsal); D,E, epigynum (ventral, dorsal). lt = lateral teeth.

DIAGNOSIS. Smaller spider with flange-shaped paraeymbium. Short MA, trifureate distally. Selerotised tegular area at base of embolus. Palpal tibia with retrodorsal apophysis terminating in a long sinuous spur (Fig. 5B).

DESCRIPTION. *Male.* CL 5.7, CW 3.7, AL 4.4, AW 2.9. Red brown eephalothorax, pale abdomen. Ratio of AME: ALE: PME: PLE is 7:10:8;11. Legs 4123. I, 20.3; II, 18.3; III, 16.7; IV, 22.9

Notation of spines. Femora: 1, D110, P011, R011; II, D111, P012, R011; III, D111, P011, R011; IV, D111, P011, R011. Patellae: III, D001. Tibiae: I, P001,V222; II, P111, V222; III, D111, P111, V222, R111; IV, D111, P111, V222, R111. Metatarsi: I, P010, V222, R010; II, P011, V221, R011; III, D110, P112, V221, R112; IV, D111, P112, V221, R112. Tarsi: III, R001; IV, R011.

♂ palp (Fig. 5A-C). Small flange-shaped paraeymbium. MA trifureate distally with prolateral, dorsal and small ventral braneh. Tibia with distal retroventral apophysis and excavated RTA with long digitiform retrolateral braneh, small eentral proeess and eurved retrodorsal apophysis terminating in long sinuous spur.

Other males were slightly smaller, 8.8 and 9.3.

Female unknown.

DISTRIBUTION (Fig. 6B). Known only from one sample eolleeted near Pioneer, NE Tasmania.

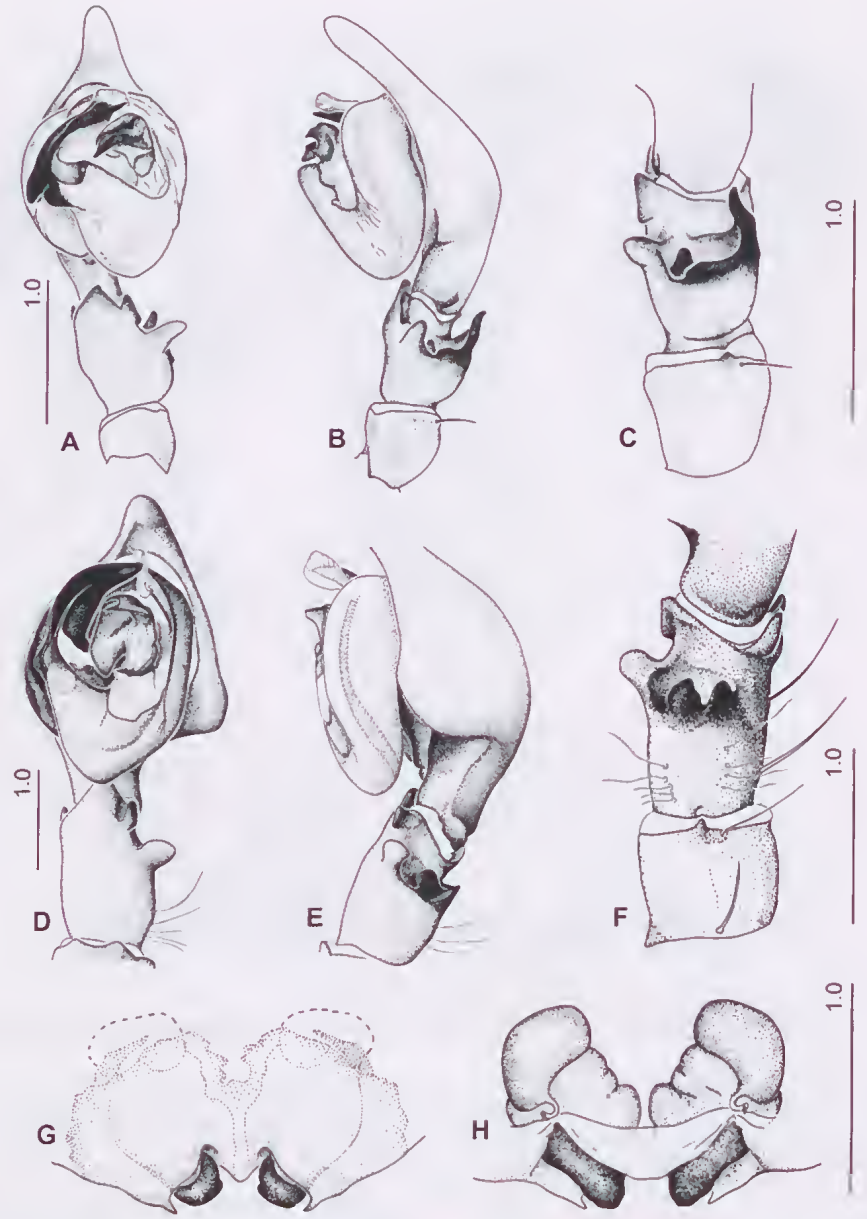

FIG. 5. A-H, *Tangana* spp. nov. A-C, *T. acuta*, ♂ palp (ventral, retrolateral, dorsal). D-F, *T. clarkei*, ♂ palp (ventral, retrolateral, dorsal). G, H, *T. harveyi*, epigynum (ventral, dorsal).

Tangana clarkei sp. nov.
(Figs 5D-F, 6B)

ETYMOLOGY. In honour of Arthur Clarke, speliologist.

MATERIAL. HOLOTYPE: ♂, Exit Cave, 43°29'S, 146°51'E, 7 Mar. 1997, A.Clarke (TM J3259). OTHER MATERIAL: juvenile, same data as holotype (TM J3316).

DIAGNOSIS. Large cave spider with very long legs. MA bifurcate distally.Retrodorsal branch of RTA bluntly pointed.

DESCRIPTION. *Male.* CL 8.7, CW 6.1, AL 7.9, AW 5.5. Coloration similar to other species but without pattern on abdomen. Posterior eye row straight, anterior row slightly recurved. Ratio of

AME: ALE: PME: PLE is 8: 10: 10: 11. Labium longer than wide, 1: 0.8. Sternum longer than wide, 1: 0.8. Legs 4123. 1, 30.9; II, 29.3; III, 28.6; IV, 38.3. Notation of spines. Femora: I, D111, P011, R021; II, D111, P102, R011; III, D111, P111, R111; IV, D111, P111, R111. Patellae: III, D001; IV, D001. Tibiae: I, P111, V222, R011; II, P111, V222, R111; III, P111, V222, R111; IV, D111, P011, V222, R111. Metatarsi: I, D010, P111, V221, R112; II, D110, P111, V222, R111; III, D110, P112, V221, R112; IV, D100, P112, V221, R112. Tarsi: III, P001, R001; IV, P001, V003, R001.

♂ palp (Fig. 5D-F).Without paracymbium. MA with large dorsal and small prolateral branches. RTA with short rounded retrolateral and pointed retrodorsal apophyses.

Female unknown.

DISTRIBUTION. (Fig. 6B). Cave spider from SW Tasmania.

Tangana harveyi sp. nov.
(Figs 5G,H, 6A)

ETYMOLOGY. In honour of Mark Harvey, one of the collectors of this spider from Victoria.

MATERIAL. HOLOTYPE. ♀, The Beeches, Victoria, 37°28'S, 145°49'E, 25 Mar.1991, Mark S. Harvey, M.E. Blosfelds (WAM 98/2046). OTHER MATERIAL: 2 juveniles, same data as holotype (WAM 98/2047-8).

DIAGNOSIS. Epigynal spermatheeae more widely separated than in other species.

DESCRIPTION. *Female.* CL 7.2, CW 4.8, AL 6.0, AW 4.0 (abdomen shrunken). Red-brown carapace; dark cardial area and five chevrons with accompanying pale spots on abdomen; pale venter. From above, posterior eye row straight, anterior row slightly recurved. Ratio of AME: ALE: PME: PLE is 8: 11: 9: 12. Labium slightly longer than wide 1: 0.9. Sternum longer than wide 1: 0.8. Legs 4123. 1, 21.2; II, 19.7; III, 17.7; IV, 23.2. Notation of spines. Femora: I, D111, P002, R011; II, D111, P111, R100; III, D111, P101, R011; IV, D111, P101, R001. Tibiae: I, P011, V222; II, P111, V222; III, D111, P111, V212, R111; IV, D111, P111, V212, R111. Metatarsi: I, P101, V221, R001; II, P011, V221, R011; III, D110, P112, V221, R112; IV, D110, P112, V221, R112. Tarsi: III, P011, R001; IV, P001, R001.

Epigynum (Fig. 5G,H). Spermatheeae more widely separated than in other species.

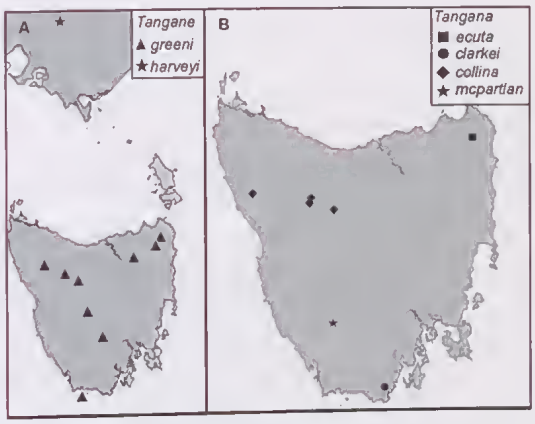

FIG. 6. A,B, Maps showing distribution of *Tangana* spp, in Tasmania and Victoria.

Male unknown.

DISTRIBUTION (Fig. 6A). One female and two juveniles from southern Victoria.This is the first record of a tasmarubriine from mainland Australia.

ACKNOWLEDGEMENTS

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MIOCENE PALYNOFLORAS FROM SUBSURFACE SEDIMENTS IN THE BUNDABERG DISTRICT

MARY E. DETTMANN AND H.TREVOR CLIFFORD

Dettmann, M.E. & Clifford, H.T. 2003 06 30: Miocene palynofloras from subsurface sediments in the Bundaberg district. *Memoirs of the Queensland Museum* **49**(1): 261-267. Brisbane. ISSN 0079-8835.

Well-preserved palynofloras extracted from fluvial sediments of the Cainozoic Elliott Formation in the Bundaberg Trough, central-eastern Queensland enable dating the formation, the age of which hitherto has been poorly constrained. Representation of the pollen taxon, *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall, in association with spores referable to *Polypodiidites usmensis* (van der Hammen) Khan & Martin, both of which are restricted to Early Miocene and younger sediments in the Capricorn Basin, confirm an age no older than the Early Miocene, and enable correlation of the Bundaberg sequence with Early Miocene fluvio-deltaic sediments penetrated by GSQ Sandy Cape 1-3R on Fraser Island. Records of *Polypodiidites usmensis* in the Fairymead beds, which underlie the Elliott Formation, indicate that the Fairymead beds are also no older than Early Miocene. ❐ *Elliott Formation, palynofloras, Miocene, Capricorn Basin.*

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Subsurface sediments in the Bundaberg area, southeastern Queensland (Fig. 1), contain an important aquifer, which is tapped as a source of groundwater, principally for sugar-cane irrigation. Fossil fruit-stones including the recently reported *Spondylostrobus symthii* F.Muell. (Dettmann & Clifford, 2002), having been recovered during the course of water-bore drilling by the Department of Natural Resources and Mines. The fruits came from a sequence of unconsolidated coarse to fine sands, silts, and interbedded clays capped by a thin sequence of Quaternary sands. The sand/silt/clay sequence is lithologically similar to the Elliott Formation, the type section of which occurs in the region (Robertson, 1979). This formation, based on its stratigraphic relationships with weathering and erosional surfaces of underlying and possibly penecontemporanous sediments, has been reported to comprise Eocene and Oligocene to Miocene sediments (Grimes, 1988). With the aim of resolving the subsurface stratigraphy and age of the important aquifer a continuously cored section, DNR 1360 0253 (Fig. 2), was drilled south of Bundaberg. Sediments sampled from this section have been palynologically analysed for age assessment and the results are detailed herein.

GEOLOGICAL SETTING

The Cainozoic history of southeastern Queensland has been one of basic volcanism associated with Paleocene break-up of the Australian plate followed by intermittent sedimentation and periods of deep weathering (Grimes, 1988). In the Bundaberg region subsurface sections penetrated basalts believed to be of Paleocene age and overlying fluvial sediments referred to the Fairymead beds that were tentatively dated as Eocene (Ellis, 1968; Foster, 1978; Robertson, 1979; Grimes, 1988) (Table 1). Outcrops of fluvial sediments believed to be younger and mapped as Elliott Formation occur in an area between the Kolan and Elliott Rivers within the Bundaberg Trough (Robertson, 1979; Day et al.,1983); the type area on the banks of the Elliott River southeast of Bundaberg has a flat to gently

TABLE 1. Stratigraphy of Upper Mesozoic and Cainozoic sediments in the Bundaberg Trough as currently recognised (Robertson, 1979; Grimes, 1988).

Age	Formation	Lithology
Pleistocene and Holocene		Estuarine, lagoonal, and fluvial sands
Early Pleistocene	Hummock Basalt	Olivine basalts
?Oligocene-Miocene	'Elliott Formation' (younger)	Sandstone, claystone
?Eocene	Elliott Formation (older)	Sandstone, claystone
?Eocene	Fairymead beds	Sandstone, claystone
?Paleocene	Pemberton Grange Basalt	Olivine basalts
Albian	Burrum Coal Measures	Coals, shales and silts

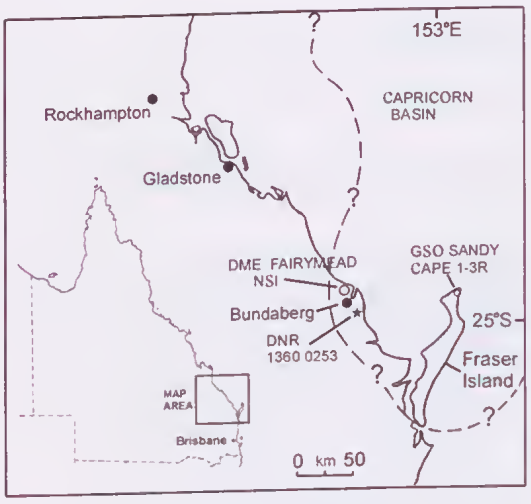

FIG. 1. Map showing location of DNR 1360 0253, 20km south of Bundaberg, Queensland.

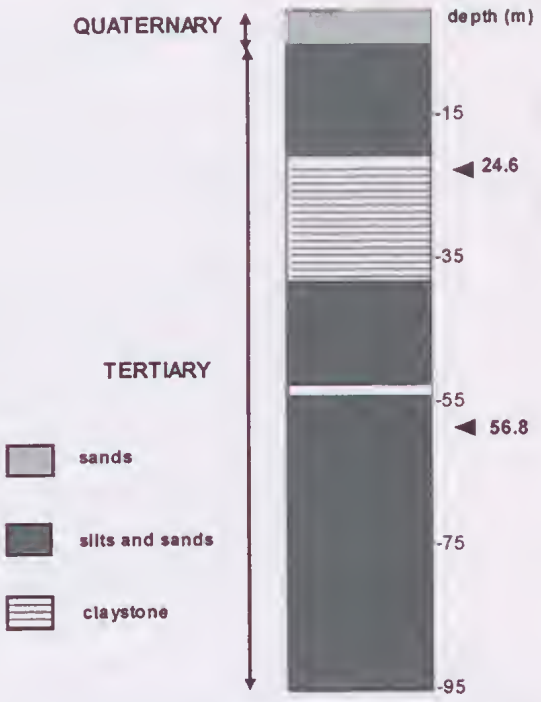

FIG. 2. Lithologic log of section cored by DNR 1360 0253 showing sampling horizons.

sloping surface. To the west of the type area, the surface buries deeply weathered Mesozoic and older rocks, but it is uncertain whether or not the surfaces are contemporaneous. In places a younger, lithologically similar unit is thought to be represented (Grimes, 1988) and this 'later Elliott Formation' may be of Oligocene to Miocene age (Grimes, 1988, p.69). Overlying Pleistocene and Holocene sands are restricted to alluvial terraces and coastal plains (Grimes, 1988).

MATERIAL AND METHODS

The sequence encountered in DNR 1360 0253, situated adjacent to Foleys Road, 20km south of Bundaberg, comprises coarse to fine sands, silts, and clays beneath Quaternary sands (Fig. 2). Several horizons were sampled and prepared for palynological analysis using standard procedures (Phipps & Playford, 1984). All samples yielded abundant fungal remains and small-to-medium-sized wood fragments were recovered from the coarse sands. Two samples (24.6 m and 56.8 m) provided well preserved assemblages of palynomorphs including diverse spores and pollen grains (Table 2). Strew slides were examined in transmitted light and photographed at magnifications up to × 1250.

Illustrated specimens are housed in the palaeontological collection of the Queensland Museum. Registered numbers (QMF) refer to the catalogue of that repository and are listed in Table 3 together with slide numbers and co-ordinates derived from a standard 'England Finder' slide.

BIOSTRATIGRAPHY AND AGE

The diverse, well-preserved palynomorph assemblages recovered from DNR 1360 0253 are dominated by angiosperm pollen with significant contributions from ferns and lesser frequencies of gymnosperm pollen (Table 2). A Tertiary age is clearly indicated by the association of *Haloragicidites harrisii*, *Nothofagidites emarcidus*, *N. asperus*, *Malvacipollis* spp., and *Myrtaceidites* spp. Qualitative/quantitative attributes of the assemblages are in accord with those reported (Wood, 1986) from an Early Miocene section penetrated by GSQ Sandy Cape 1-3R located on Fraser Island and some 100km E of Bundaberg (Fig. 1). Specifically, the Bundaberg palynofloras and those from between 421.65-433.5m in Sandy Cape 1-3R share high frequencies of fern spores, including significant representation (>10%) of *Cyathidites paleospora*, together with *Polypodiidites* spp. and *Crassoretitriletes vanraadshooveni*. The associated angiosperm pollen florules include common *Haloragicidites harrisii*, *Rhoipites*, and *Nothofagidites* coupled with infrequent *Clavastephanocolporites meleosus* and *Canthiumidites bellus* (Wood,

1986) (Table 2). This Sandy Cape 1-3R section includes fluvio-deltaic sediments containing rotaliid and miliolid foraminifers at 425m; overlying calcareous sandstones and calcarinites contain foraminiferal associations of Early Miocene age (Palmieri, 1984). The fluvio-deltaic beds are believed to express deposition early in a transgressive episode initiated during the Early Miocene; correlative sediments occur in several sections to the north in the Capricorn Basin, offshore from Rockhampton (Palmieri, 1984). Two of the Capricorn Basin sections, AGO Aquarius 1 and AGO Capricorn 1, yielded diverse palynofloras (Hekel, 1972) that share many of the features of those from the Sandy Cape and Bundaberg sections. They contain moderate frequencies of *Haloragicidites harrisii*, *Nothofagidites*, *Rhoipites*, and fern spores. Amongst the fern taxa are rare *Crassoretitriletes vanraadshooveni* and common *Polypodiidites*, including *P. usmensis*, which has first appearances in Miocene sediments (Hekel, 1972).

The Sandy Cape 1-3R fluvio-deltaic sediments overly two basalt flows, the lower of which is underlain by marine sediments containing foraminiferids of late Oligocene age (Grimes, 1982; Palmieri, 1984). Between the two basalt flows are deltaic sediments; palynofloras from these sediments (537-539.4 m) differ from those at 421.65-433.5 m above the basalts in containing high frequencies of *Haloragicidites harrisii*, low frequencies of fern spores, and *Malvacearumpollis mannanensis* (Wood, 1986).

In summation, evidence from marine sections in the Capricorn Basin reveals that *Polypodiidites usmensis* and *Canthiumidites bellus* are restricted to Early Miocene and younger sediments. The association of these two taxa in terrestrial sediments between 24.67 and 56.83 m in DNR 1360 0253 near Bundaberg argues for an age no older than Early Miocene.

The only other Cainozoic sediments in the region from which palynological data have been published are from the Fairymead beds in DME Fairymead NS 1 (Robertson, 1979) (Fig. 1, Table 1). A sample from 61.7m in this well provided common *Haloragicidites harrisii,* infrequent *Nothofagidites* and proteaceous grains in association with *Polypodiidites usmensis* (Foster, 1979). Occurrence of the last mentioned taxon implies an age no older than Early Miocene. Such a dating raises the question of whether or not the Elliott Formation and Fairymead beds were deposited contemporaneously. Foster (1979) had argued for a late Early Eocene age of the Fairymead palynoflora based on its broad similarity to palynofloras of the *Proteacidites asperopolus* Zone of southeastern Australia as defined by Stover & Partridge (1973). He also considered that palynofloras from the upper fluvio-deltaic sediments in GSQ Sandy Cape 1-3R were dominated by taxa restricted to Eocene sediments in southeastern Australia, but suggested these may have been reworked (Foster, 1978).

From present evidence, first appearances of *P. usmensis* and *C. bellus* in the Capricorn Basin may be earlier than in the more southerly basins of Australia. *C. bellus*, the nominate species for the *C. bellus* Zone of the Gippsland Basin and the *C. bellus* equivalent Zone in the Murray Basin has documented first appearances in those regions as late Early Miocene and last appearances in the *M. galeatus* Zone of Pliocene age (Stover & Partridge, 1973; Macphail, 1996). This contrasts to the appearances of the pollen taxon in foraminiferal Zone N4 (of Palmeiri, 1986) of earliest Miocene age in the Sandy Cape section. *P. usmensis*, a spore taxon with affinities with the fern *Stenochlaena* is known from the Murray Basin where it is restricted to sediments of the *C. bellus* Zone equivalent dated as late Early – Middle Miocene age (Macphail, 1996); in the Capricorn Basin the species ranges from earliest Miocene (foraminiferal Zone N4) to Pliocene age (Hekel, 1972). Wood (1986) advanced evidence for the disparate stratigraphic ranges of several palynomorph taxa in Tertiary sediments of Queensland and those of more southerly regions of Australia; further evidence has been subsequently detailed by Beeston (1994) and Dettmann & Clifford (2000).

ACKNOWLEDGEMENTS

Mr Peter Baker, formerly of the Department of Natural Resources and Mines, Bundaberg is thanked for providing sediment samples and logs of DNR 1360 0253. We are especially grateful to Dr Vince Palmieri for helpful discussions and reviewing an early draft of the manuscript. We thank Dr Mike Macphail and Dr John McKellar for their helpful reviews of the manuscript. MED thanks the Director, Queensland Museum for providing facilities and acknowledges support from the Australian Research Council during tenure of a Senior Research Fellowship.

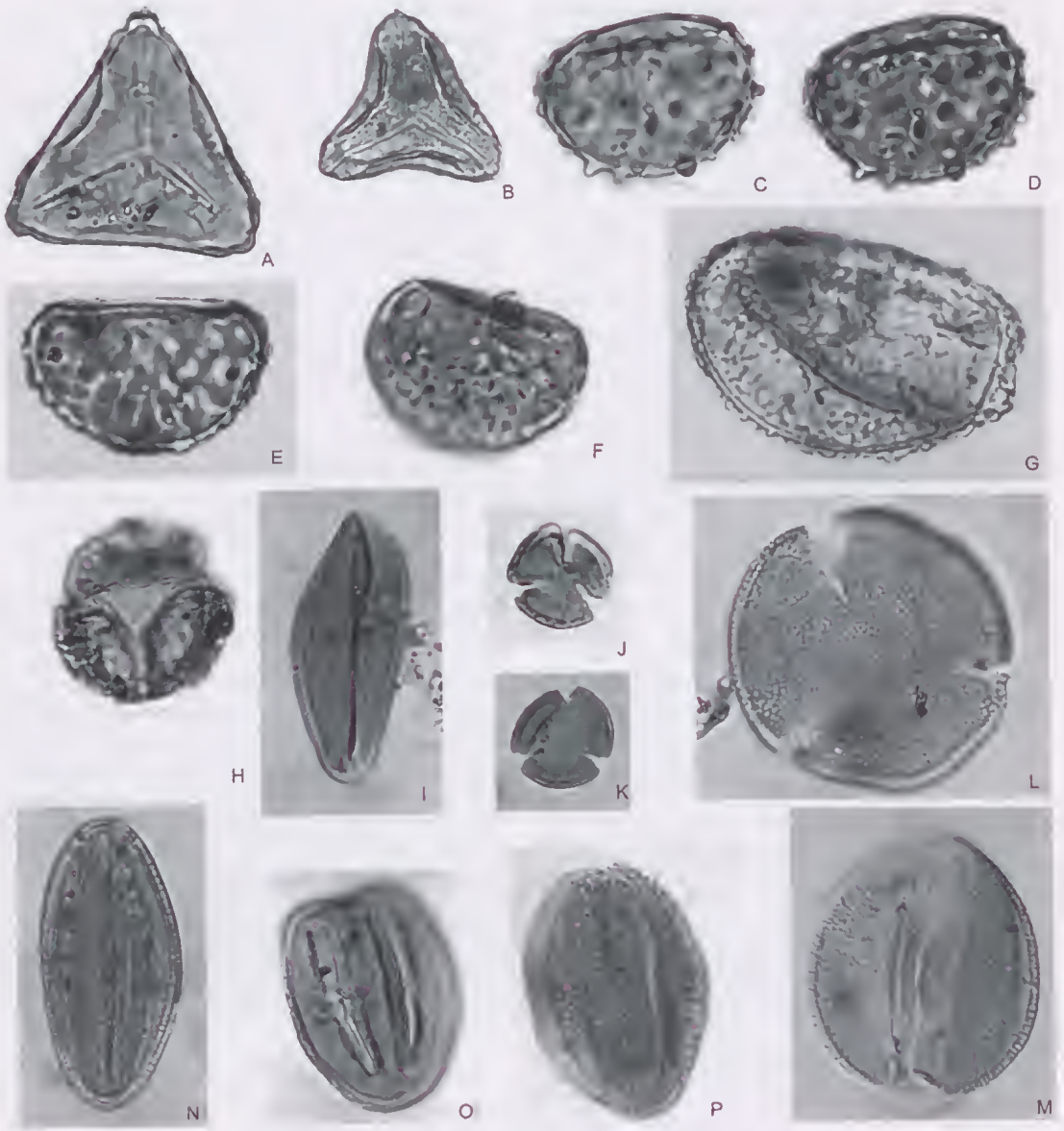

FIG. 3. A-G, spores, ×750 and H-P, pollen, ×1000 from DNR 1360 0253 borehole. A, *Gleicheniidites* sp.; B, *Dictyophyllidites arcuatus* Pocknall & Mildenhall; C, D, *Polypodiidites usmensis* (van der Hammen) Khan & Martin, optical section and high focus respectively; E, *Polypodiidites speciosus* (Harris) Khan & Martin; F, *Microfoveolatosporites* sp.; G, *Peromonolites* sp.; H, *Dacrycarpites australiensis* Cookson & Pike; I, *Arecipites* sp.; J, K, *Tricolpites* sp. 1 polar views of two specimes; L, M, *Tricolpites* sp. 2, specimens in polar and lateral aspect respectively; N, *Tricolpites* sp. 3; O,P, *Rhoipites sphaerica* (Cookson) Pocknall & Crosbie, lateral aspect, optical section and high focus respectively.

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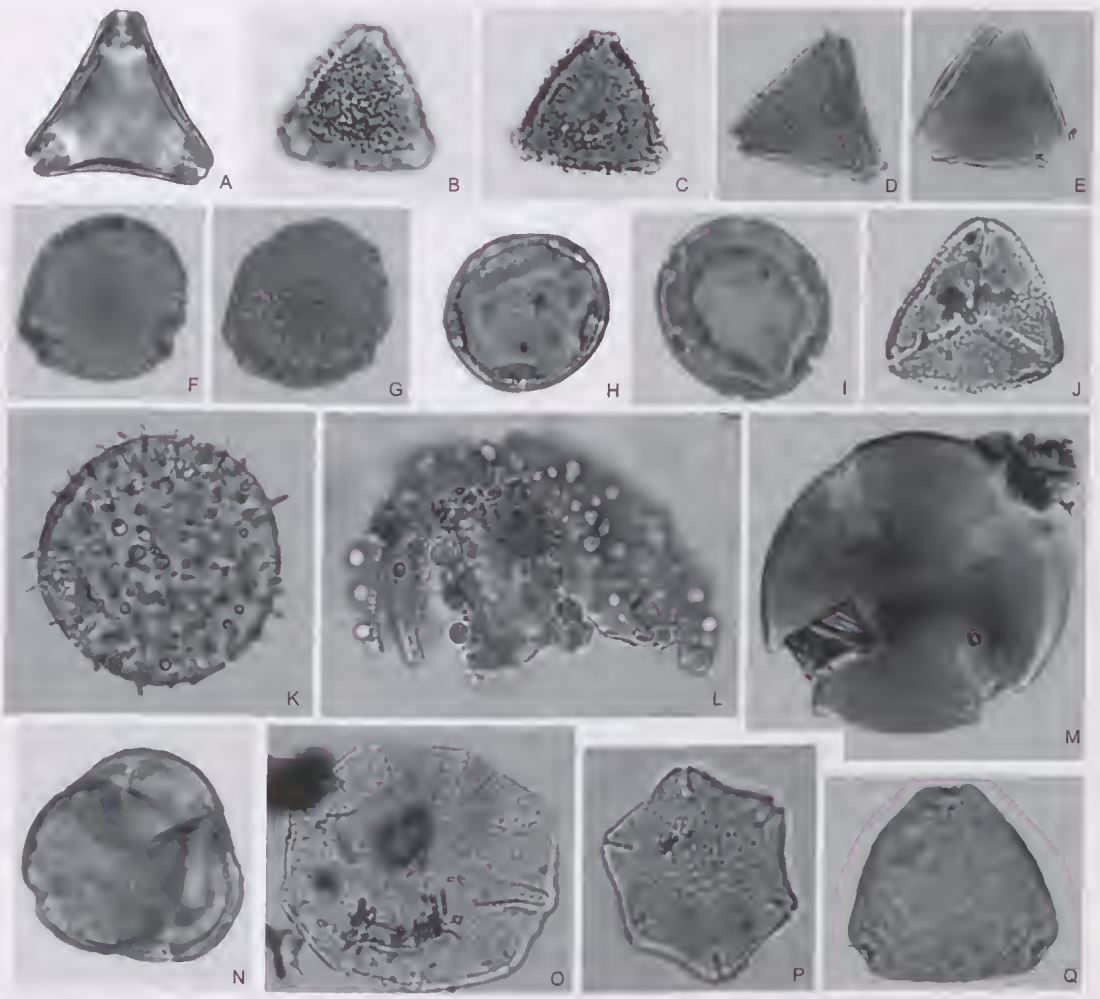

FIG. 4. Pollen, ×1000. A, *Proteacidites ivanhoensis* Martin; B, C, *Propylipollis pseudomoides* (Stover) Dettmann & Jarzen, high focus and optical section respectively; D, *Propylipollis pseudomoides* (Stover) Dettmann & Jarzen; E, *Lewalanipollis* sp.; F, G, *Canthinmidites bellus* (Stover & Partridge) Mildenhall & Pocknall, optical section and high focus respectively; H, *Polyorificites oblatus* Martin; I, *Haloragacidites suttorensis* Beeston; J, *Cupanieidites reticularis* Cookson & Pike; K, *Malvacipollis* sp.; L, *Clavastephanocolporites meleosus* Martin, Macphail & Partridge; M, *Tetracolporites* sp.; N, *Ericipites* sp.; O, *Nothofagidites asperus* (Cookson) Stover & Evans; P, *Nothofagidites emarcidus* (Cookson) Stover & Evans; Q, *Haloragacidites harrisii* (Couper) Harris.

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1979. Early Tertiary (Eocene) miospores from Fairymead NS 1. Appendix 2 in Robertson, A.D. 1979. Revision of the Cainozoic geology between

TABLE 2. Palynomorph distribution in DNR 1630-0253, 20km S of Bundaberg. Percentages derived from counts of 200 palynomorphs per sample; + denotes present in sample, but not in count.

Palynomorph Taxa	Affinity	Depth	
		24.67-.75m	56.8-.83m
Ferns:			
Azolla Lam., microsporangia	Salviniaceae, *Azolla*	+	
Crassiretitriletes vanraadshoovenii Germeraad et al.	Schizaeaceae, *Lygodium microphyllum*-type	+	
Cyathidites paleospora (Martin) Alley & Broadbridge	Cyatheaceae, *Cyathea*	12.5	16.5
Dictyophyllidites arcuatus Pocknall & Mildenhall	?Gleicheniaceae	3.5	2
Foveosporites sp. of Wood (1986)	?Ophioglossaceae		+
Gleicheniidites sp.	Gleicheniaceae	+	
Ischyosporites sp.	Dicksoniaceae		+
Laevigatosporites ovatus Wilson & Webster	Filicales		10.5
Microfoveolatosporites sp. (=*Polypodiisporites* sp. of Wood, 1986, fig. 3.6)	Filicales		+
Peromonolites spp.	Filicales		+
Polypodiidites speciosus (Harris) Khan & Martin	Polypodiaceae	+	4
P. usmensis (van der Hammen) Khan & Martin	Blechnaceae, *Stenochlaena*	1	
Gymnosperms:			
Araucariacites australis Cookson	Araucariaceae		1
Dacrycarpites australiensis Cookson & Pike	Podocarpaceae, *Dacrycarpus*	2	2
Lygistepollenites florinii (Cookson & Pike) Stover & Evans	Podocarpaceae, *Dacrydium*	1	1
Podocarpidites ellipticus Cookson	Podocarpaceae, *Podocarpus*		3
Trichotomosulcites subgranulatus Couper	Podocarpaceae	1.5	
Monocotyledons:			
Arecipites sp.	?Arecaceae? Liliaceae	4.5	1
Cyperaceaepollis sp.	Cyperaceae	+	
Dicotyledons:			
Canthiumidites bellus (Stover & Partridge) Mildenhall & Pocknall	Rubiaceae, *Randia*	+	+
Clavastephanocolporites meleosus Martin, Macphail & Partridge	Alangiaceae, *Alangium villosum*-type		+
Cupanieidites reticularis Cookson & Pike	Sapindaceae, Cupanieae	+	+
Ericipites sp.	?Epacridaceae		+
Haloragacidites cainozoicus Cookson & Pike	Casuarinaceae		+
H. harrisii (Couper) Harris	Casuarinaceae	36.5	12.5
H. suttorensis Beeston	Unidentified angiosperm	15.5	2.5
Polyorificites oblatus Martin	Unidentified angiosperm	+	
Ilexipollenites anguloclavatus McIntyre	Aquifoliaceae, *Ilex*		2
Lewalanipollis sp.	Proteaceae	+	+
Malvacipollis subtilis Stover & Partridge	Euphorbiaceae, *Austrobuxus*	5	3
Malvacipollis spp.	Euphorbiaceae	2	+
Myrtaceidites parvus-mesonesus (Cookson & Pike) Stover & Evans	Myrtaceae	1	1
Nothofagidites asperus (Cookson) Stover & Evans	Nothofagaceae, *Nothofagus Lophozonia*		5.5
N. emarcidus (Cookson) Stover & Evans	Nothofagaceae, *Nothofagus Brassospora*	2	17.5
Periporopollenites sp.	Unidentified angiosperm		+
Propylipollis pseudomoides (Stover) Dettmann & Jarzen	Proteaceae	6	3
Proteacidites ivanhoensis Martin	Proteaceae, *Helicia/Macadamia*		+
Proteacidites spp.	Proteaceae	2	2
Rhoipites sphaerica (Cookson) Pocknall & Crosbie	Unidentified angiosperm	2	5
Rhoipites microreticulatus (Harris) Macphail et al.	Unidentified angiosperm	2	5
Rhoipites spp.	Unidentified angiosperm	+	+
Tetracolporites sp.	Unidentified angiosperm		+
Tricolpites sp. 1	Unidentified angiosperm	+	+
Tricolpites sp. 2	Unidentified angiosperm	+	+
Tricolpites sp. 3	Unidentified angiosperm	+	

TABLE 3. Register of illustrated speeimens.

Taxon	Figure	Prep./Slide	England Finder Co-ordinates	Catalogue no.
Arecipites sp.	3I	M104/C1	S54	QMF51095
Canthiumidites bellus	4F,G	M104/C1	V40	QMF51096
Clavastephanocolporites meleosus	4L	M101/F1	K36/4	QMF51094
Cupanieidites reticularis	4J	M101/F2	T41	QMF51097
Dacrycarpites australiensis	3H	M101/F1	P53	QMF51098
Dictyophyllidites arcuatus	3B	M101/F1	D37	QMF51099
Ericipites sp.	4N	M101/C2	K19	QMF51100
Gleicheniidites sp.	3A	M104/F2	X30/2	QMF51101
Haloragicidites harrisii	4Q	M104/F2	U33/1	QMF51102
H. suttorensis	4I	M104/F1	S41	QMF51103
Lewalanipollis sp.	4E	M104/C2	U23/1	QMF51105
Malvacipollis sp.	4K	M101/F2	P50/4	QMF51106
Microfoveolatosporites sp.	3F	M101/F1	F18	QMF51107
Nothofagidites asperus	4O	M101/F1	O51	QMF51108
N. emarcidus	4P	M101/F1	M54/3	QMF51109
Peromonolites sp.	3G	M101/F1	M19/2	QMF51110
Polyorificites oblatus	4H	M104/C1	O23	QMF51104
Polypodiidites speciosus	3E	M101/F1	Q54	QMF51111
P. usmensis	3C,D	M104/F2	L49/3	QMF51112
Propylipollis pseudomoides	4B,C	M104/C1	N50/4	QMF51114
	4D	M104/C2	G36/2	QMF51115
Proteacidites ivanhoensis	4A	M101/F1	F28/3	QMF51113
Rhoipites sphaerica	3O	M101/C2	D37	QMF51116
	3P	M104/C1	T36	QMF51117
Tetracolporites sp.	4M	M101/C1	O41/3	QMF51118
Tricolpites sp. 1	3J	M104/C1	O49/1	QMF51119
	3K	M104/C2	P44/4	QMF51120
Tricolpites sp. 2	3L	M101/F2	L50/3	QMF51121
	3M	M101/C2	L14	QMF51122
Tricolpites sp. 3	3N	M104/C2	J49/3-4	QMF51123

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A NEW GENUS OF HENICOPID CENTIPEDE (CHILOPODA: LITHOBIOMORPHA) FROM NEW CALEDONIA

GREGORY D. EDGECOMBE

Edgecombe, G.D. 2003 06 30: A new genus of henicopid centipede (Chilopoda: Lithobiomorpha) from New Caledonia. *Memoirs of the Queensland Museum* 49(1): 269-284. Brisbane. ISSN 0079-8835.

Two species from New Caledonia, *Easonobius tridentatus* gen. et sp. nov. and *Paralamyctes humilis* Ribaut, 1923, together represent a new genus of Henicopini. South African species formerly classified together with *Easonobius humilus* in *Analamyctes* Chamberlin, 1955, are distantly allied, members of *Paralamyctes* (*Paralamyctes*) Pocock, 1901. Morphological characters of *Easonobius*, including electron microscopic study of the head, indicate membership in the *Lamyctes-Henicops* Group. Parsimony analysis favours a closest relationship between *Easonobius* and the Australasian genus *Henicops* Newport, 1844. The type species of *Lamyctes* (*Eumyctes*) Chamberlin, 1951, shares apomorphic characters with the Cape genus *Lamyctopristus* Attems, 1928, to which *Eumyctes* is transferred. ❐ *Chilopoda*, *Lithobiomorpha*, *Henicopidae*, Easonobius, *New Caledonia*, *taxonomy*, *phylogeny*.

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Paralamyctes humilis Ribaut, 1923, was named based on a single, small male from Oubatche in northeastern New Caledonia. Subsequently, Chamberlin (1955) reassigned *P. humilis* to the genus *Analamyctes* Chamberlin, 1955, and, more precisely, to an invalidly erected subgenus *Capolamyctes*. *Analamyctes* (*Analamyctes*) was conceived as occurring in Argentina (the type species *A. tucumanus* Chamberlin, 1955, from Tucumán Province, and *Paralamyctes andinus* Silvestri, 1903, from Mendoza Province). *Analamyctes* (*Capolamyctes*) received species from the Cape region of South Africa (*Paralamyctes asperulus* Silvestri, 1903; *P. levigatus* Attems, 1928; *P. tabulinus* Attems, 1928) together with the New Caledonian *P. humilis*.

In a revision of *Paralamyctes* Pocock, 1901, Edgecombe (2001) dismissed Chamberlin's (1955) reassignment of South African species to *Analamyctes*, these taxa being accommodated within a monophyletic *Paralamyctes* (*Paralamyctes*) Pocock, 1901. This conclusion is supported by both morphological (Edgecombe, 2003a) and molecular data (Edgecombe & Giribet, 2003a). A reconsideration of *Analamyctes* was made possible by a restudy of its type species, *A. tucumanus*. Argentinian species of *Analamyctes* are members of a *Lamyctes-Henicops* Group, only distantly allied to *P.* (*Paralamyctes*) (Edgecombe, 2003b).

The present study reconsiders *Paralamyctes humilis*, which until now has defied phylogenetic placement. New collections made by G. B. Monteith (Queensland Museum) in New Caledonia include additional specimens of both sexes of this species, as well as specimens that represent another, closely related species. Morphology of these species is documented by electron microscopy, including mouthparts that have proven useful in henicopid systematics, and they are are coded for their morphological characters in a dataset for henicopid phylogeny.

Institutional abbreviations cited in this work are: AM – Australian Museum, Sydney; MNHN – Museum National d'Histoire Naturelle, Paris; QM – Queensland Museum, Brisbane; ZMB – Museum für Naturkunde, Berlin. Morphological terminology is as explained by Edgecombe (2001: 203). Drawings were prepared with a camera lucida attachment to a Leica MZ12. Scanning electron microscopy used a Leo 435VP with a Robinson backscatter detector, and digital images assembled into plates with Photoshop.

SYSTEMATICS

Easonobius gen. nov.

partim *Analamyctes* (*Capolamyctes*) Chamberlin, 1955 nomen nudum.

TYPE SPECIES. *Easonobius tridentatus* gen. et sp. nov.

ETYMOLOGY. In honour of Dr Edward H. Eason (1915-1999), for his contributions to lithobiomorph systematics, with the standard suffix, -obius.

DIAGNOSIS. Member of *Lamyctes-Henicops* Group lacking pseudoporodont (shared with

Henicops and *Analamyctes*); posterior angles of tergites 7, 9, 11 and 13 produced (shared with *Henicops* and *Lamyctopristus*); dental margin of maxillipede coxosternite with 2+2 or 3+3 teeth; tarsi of all legs bipartite (shared with *Analamyctes*); coxal process of first maxilla with laciniate or plumose setae near dorsal margin (shared with *Henicops*); mandible with single row of exclusively bipinnulate aciculae; last distal spinose projection on tibia of leg 13; first genital sternite of ♂ undivided (plesiomorphies excluding membership in *Henicops*). Antenna with 26-33 articles; tergite of intermediate segment with strongly concave posterior margin.

ASSIGNED SPECIES. *Paralamyctes humilis* Ribaut, 1923.

DISCUSSION. Chamberlin distinguished two subgenera of *Analamyctes* in a key, using a single character. *Analamyctes* (*Analamyctes*), grouping the Argentinian species *A. tucumanus* and *A. andinus*, was defined based on 'posterior angles of none of the dorsal plates produced'. *Analamyctes* (*Capolamyctes*) grouped *A. humilis* with three nominal South African species of *Paralamyctes* (Edgecombe, 2001, 2003a). *Analamyctes* (*Capolamyctes*) was distinguished based on 'posterior angles of tergites 9, 11 and 13 or 7, 9, 11 and 13 produced'. Though Chamberlin was explicit about the membership and diagnosis of *Capolamyctes*, he neglected to designate a type species. The name fails Article 13.3 of the ICZN Code, and is dismissed as a *nomen nudum*. As argued in detail below, the original concept of *Capolamyctes* delimits a polyphyletic group. Of Chamberlin's assigned species, only *Paralamyctes humilis* is at all closely related to the type species of *Analamyctes*.

Easonobius resembles *Analamyctes* in having bipartite tarsi on all legs, a state restricted to these taxa within the *Lamyctes-Henicops* Group (but possibly plesiomorphic by comparison to *Paralamyctes* and Zygethobiini). *Easonobius* most obviously differs from *Analamyctes* in its tergal shapes, as used in Chamberlin's (1955) subgeneric scheme, with projections on TT7, 9, 11 and 13 versus nearly transverse margins in *Analamyctes*. This does not in itself obviate a close relationship, since tergite projections occasionally vary within some well defined henicopine clades, such as *Paralamyctes* (*Haasiella*), e.g., present in *P.* (*H.*) *subicolus* and *P.* (*H.*) *trailli*; absent in *P.* (*H.*) *cammooensis* and *P.* (*H.*) *ginini*.

Easonobius is resolved as most closely related to *Henicops* Newport, 1844, in the best supported phylogenetic analyses, described below. However, several apomorphic characters unite Australian and New Zealand members of *Henicops* in the traditional sense (e.g., Attems, 1914, 1928; Chamberlin, 1920; Archey, 1937) as a clade that excludes *Easonobius*. These characters (numbered as in Table 1) include a subdivision of the basitarsus indicated by paired larger setae (40:1), the first genital sternite of the ♂ being divided longitudinally into two sclerites (43:1), the distitarsus of leg 15 being divided into tarsomeres (53:1), and more setose gonopods in both sexes. *Henicops* as traditionally delimited is strongly supported (jackknife frequency 99%; Fig. 8), and it is not expanded in scope and rediagnosed to incorporate the species here recognised as *Easonobius*.

Comparable in several respects is a group of mostly Southern African species referred to *Lamyctes* (*Eumyctes*) Chamberlin, 1951 [type *Henicops sinuatus* Porat, 1893] and *L.* (*Neomyctes*) Chamberlin, 1951 [type *Lamyctes* (*Neomyctes*) *ergus* Chamberlin, 1951]. These are distinguished from typical *Lamyctes* Meinert, 1868, by their projections on tergites 9, 11 and 13. The style of tergite projections in species such as *L.* (*Eumyctes*) *sinuatus* is as in *Easonobius*, and these species also share a strongly concave posterior margin to the tergite of the intermediate segment (Attems, 1909, fig. 53). Chamberlin's (1951 versus 1955) distinction between *Eumyctes*/*Neomyctes* and *Analamyctes* (including *E. humilus*) placed fundamental weight on the absence or presence of a tarsal articulation. A closer relationship can be proposed for the type of *Eumyctes*, *L.* (*E.*) *sinuatus*, and the Cape genus *Lamyctopristus* Attems, 1928, than the former shares with *Easonobius*. *Lamyctes* (*Eumyctes*) *sinuatus* has dense, strongly developed tuberculation on the tergites, to a degree observed only in *Lamyctopristus* amongst all known Henicopidae. In both *L.* (*E.*) *sinuatus* and *L. granulosus* (=*L. validus*?), tuberculation is more pronounced on the male than on the female (Lawrence, 1955: 23), e.g., being well developed on the head shield of the male. These species are also similar, and resemble *Henicops* Newport, 1844, in having tergite projections and distal spinose projections on the tibia of leg 14. They share other peculiar characters in addition to their tergal tuberculation. In *Lamyctopristus validus* as well as *Lamyctes* (*Eumyctes*) *sinuatus*, the tarsi of

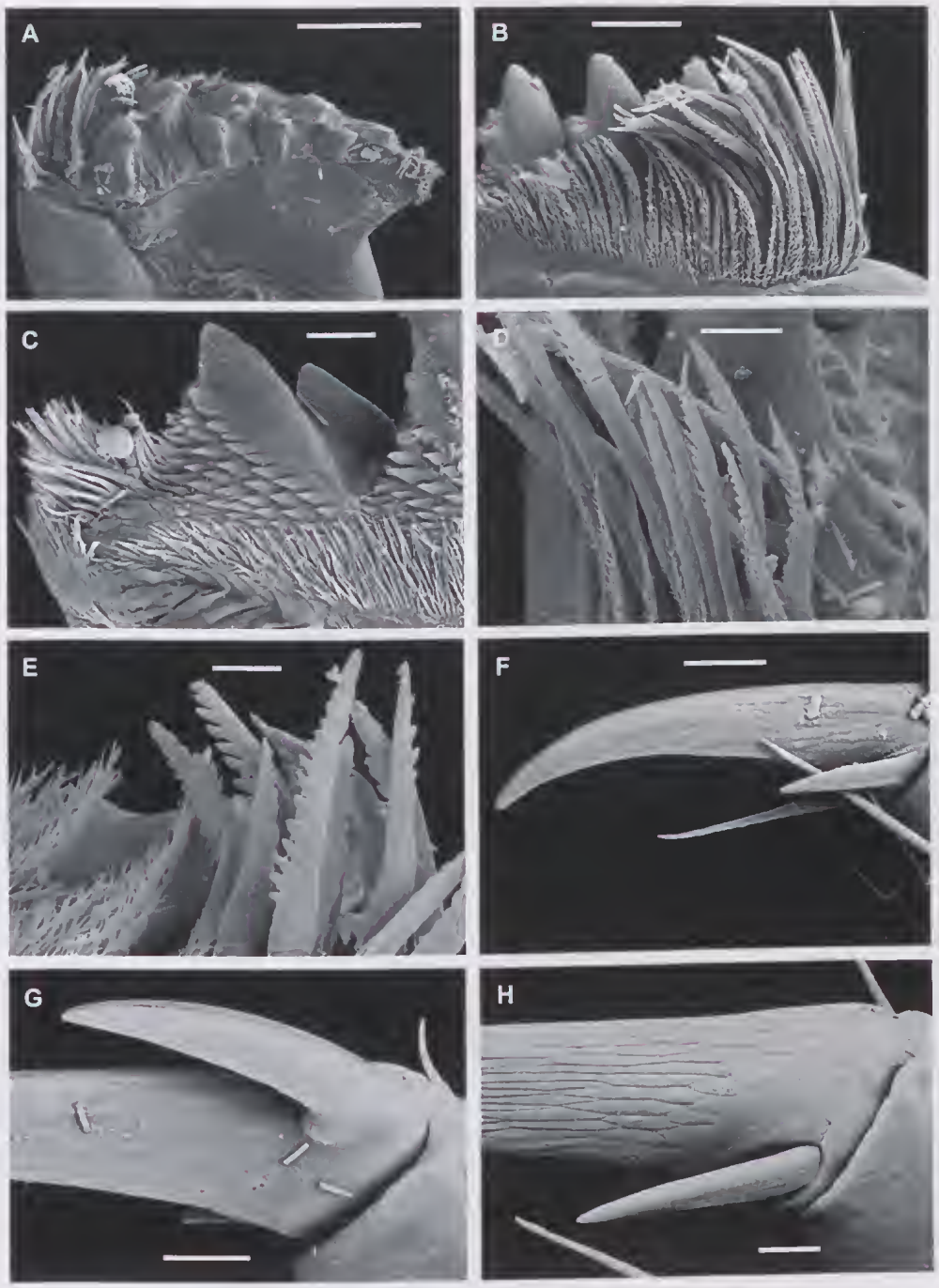

FIG. 1. A-F, *Lamyctopristus* (*Eumyctes*) *sinuatus* (Porat, 1893). ZMB 4962, ♀, Kamaggas, Northern Cape Province, South Africa. A-E, mandible. A, medial view of gnathal edge, scale 100μm; B, ventral part of gnathal edge, scale 50μm; C, dorsalmost tooth and furry pad, scale 20μm; D-E, aciculae, scales 20μm, 10μm; F, anterior view of pretarsus, scale 30μm. G, *Henicops maculatus* Newport, 1844. Anterior view of pretarsus of leg 14, scale 15μm. H, *Paralamyctes* (*Paralamyctes*) *asperulus* Silvestri, 1903. SAM-ENW-C5314. Anterior view of pretarsus of leg 14, scale 15μm.

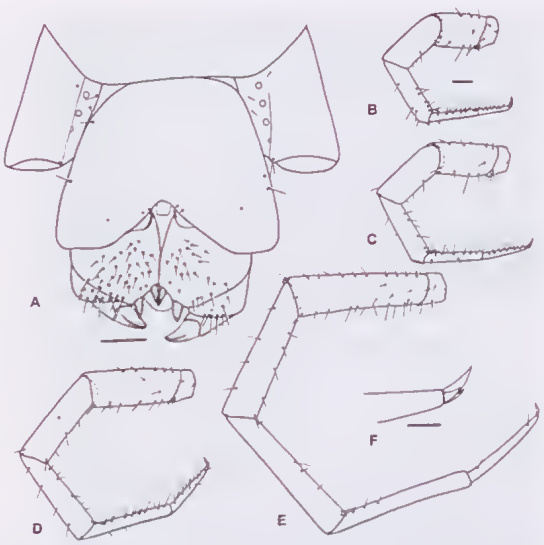

FIG. 2. A, *Lamyctopristus* (*Eumyctes*) *sinuatus* (Porat, 1893). ZMB 4962, ♀, Kamaggas, Northern Cape Province, South Afriea, terminal segments and gonopods, scale 200µm. B-F, *Easonobius tridentatus* gen. et sp. nov. QM S60291, ♀, Pie d'Amoa. Scale in B applies to C-E. B, leg 12, scale 200µm; C, leg 13; D, leg 14; E, leg 15; F, distal part of tarsus and pretarsus of leg 15, scale 100µm.

anterior legs have a distinct curvature within the distitarsal portion, this occurring despite the lack of articulations. Mandibular characters (Fig. 1) are also consistent with a close relationship between *L.* (*Eumyctes*) *sinuatus*, *Lamyctopristus* and *Henicops*. The former species has a large number of aciculae on the mandible, with the density and arrangement of the aciculae two-deep (Fig. 1B, D), rather than a single row, being otherwise observed only in *Lamyctopristus validus* (Edgecombe, 2003b, fig. 34D) and in all species of *Henicops* (Edgecombe et al., 2002, fig. 5C). Also as in *Henicops* and *Easonobius*, but not *Lamyctes*, the accessory denticles on the dorsal-most tooth of the mandible are simple, angular elements (Fig. 1C), rather than multifurcating scales (Edgecombe et al., 2002, fig. 7B, for *Lamyctes emarginatus*). As well, the novel expansion of basal article of the female gonopod in *Lamyctopristus* may have a precursor in the relative breadth of this article in *L.* (*E.*) *sinuatus* (Fig. 2A). Phylogenetic analysis including these characters (see below) recognises *L.* (*Eumyctes*) *sinuatus* as more closely related to *Lamyctopristus* than to *Lamyctes*. To incorporate this relationship into the classification, *Eumyctes* is reassigned to *Lamyctopristus*.

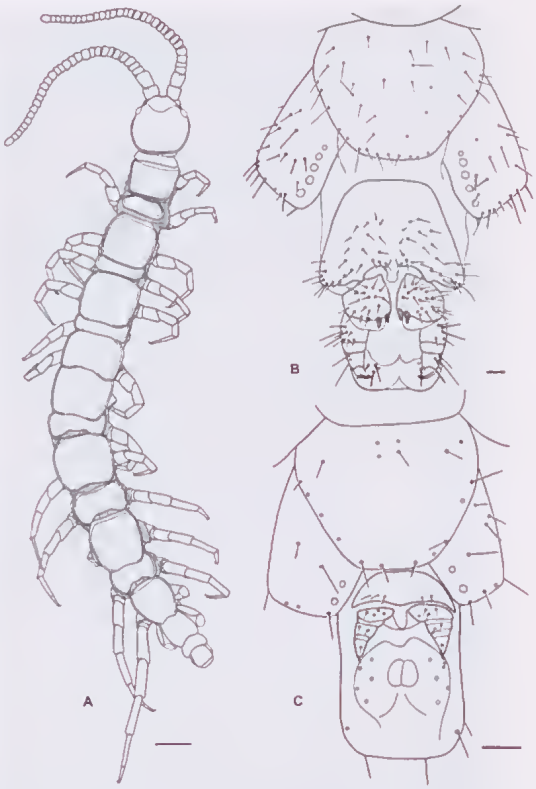

FIG. 3. *Easonobius tridentatus* gen. et sp. nov. A, MNHN P244, holotype ♀, Pie d'Amoa, dorsal habitus, scale 1mm; B, QM S60291, ♀, Pie d'Amoa, terminal segments and gonopods, scale 100µm. C, QM S60292, ♂, Aoupinie, terminal segments and gonopods, scale 100µm.

Easonobius tridentatus sp. nov.
(Figs 3-6)

DIAGNOSIS. *Easonobius* with width of head shield up to 1.5mm; penultimate and preceding few antennal articles as wide as or wider than long; dental margin of maxillipede coxosternite moderately wide, gently convex, with 3+3 teeth; Tömösváry organ small; a few lacinate setae on coxal process of first maxilla; posteromedian embayment in margin of T7 transverse or faintly convex; short, spinule-like setae on tergites and along tergal margins.

ETYMOLOGY. For the three teeth on the dental margin of the maxillipede coxosternite.

MATERIAL. HOLOTYPE. MNHN P244, ♀ (Fig. 3A), Pie d'Amoa, N slopes, Province Nord, New Caledonia, 20°58'S 165°17'E, 500m, GB. Monteith, 24 November 2001-31 January 2002. PARATYPES. QM S60291, ♀

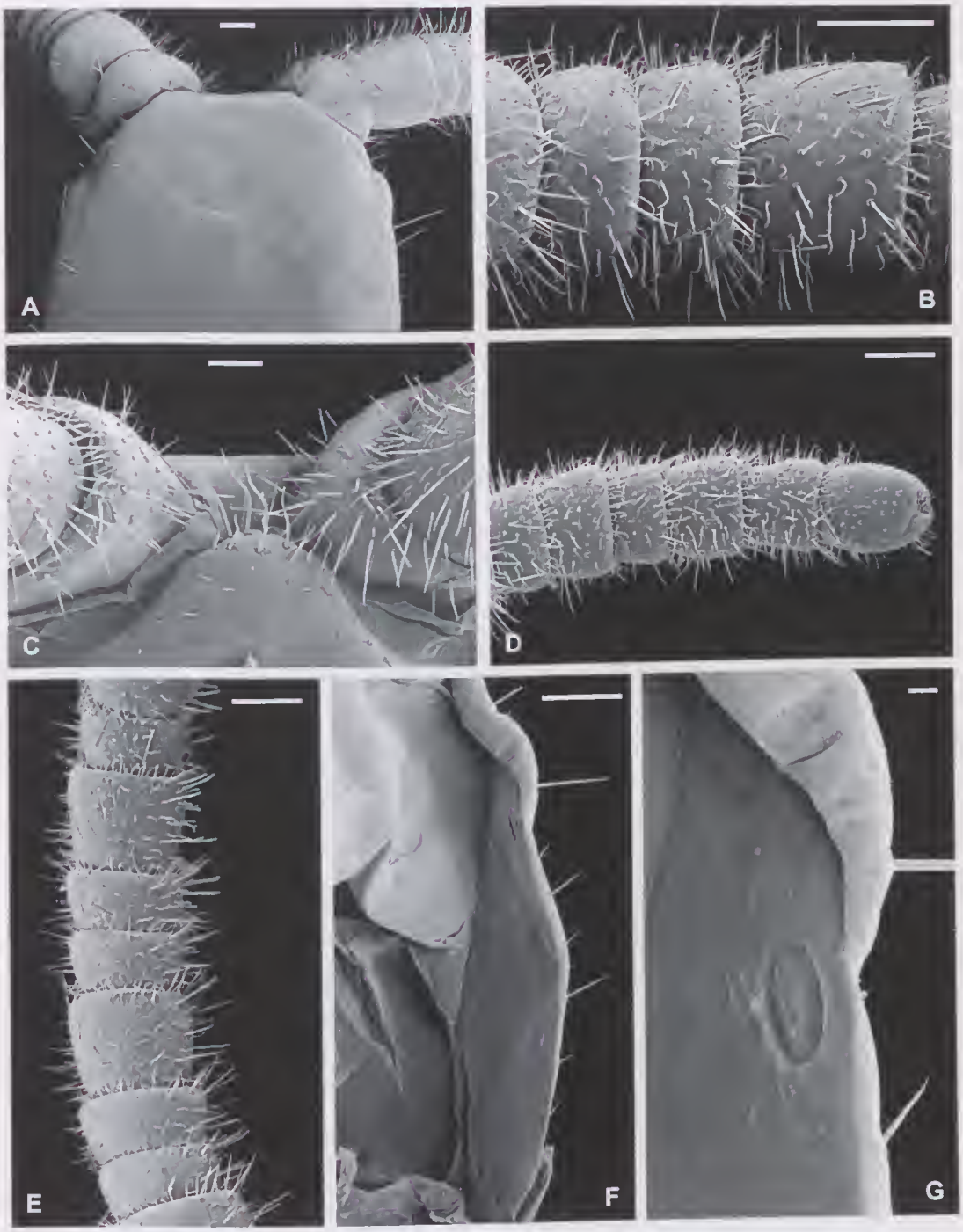

FIG. 4. *Easonobius tridentatus* gen. et sp. nov. SEMs, scales 100µm except G, 10µm. QM S60291, ♀, Pic d'Amoa. A, dorsal view of anterior part of head, proximal part of antennae; B,D,E, dorsal side of antenna; C, ventral view of clypeus and sclerotised bridge between antennae; F-G, cephalic pleurite and detail of Tömösváry organ.

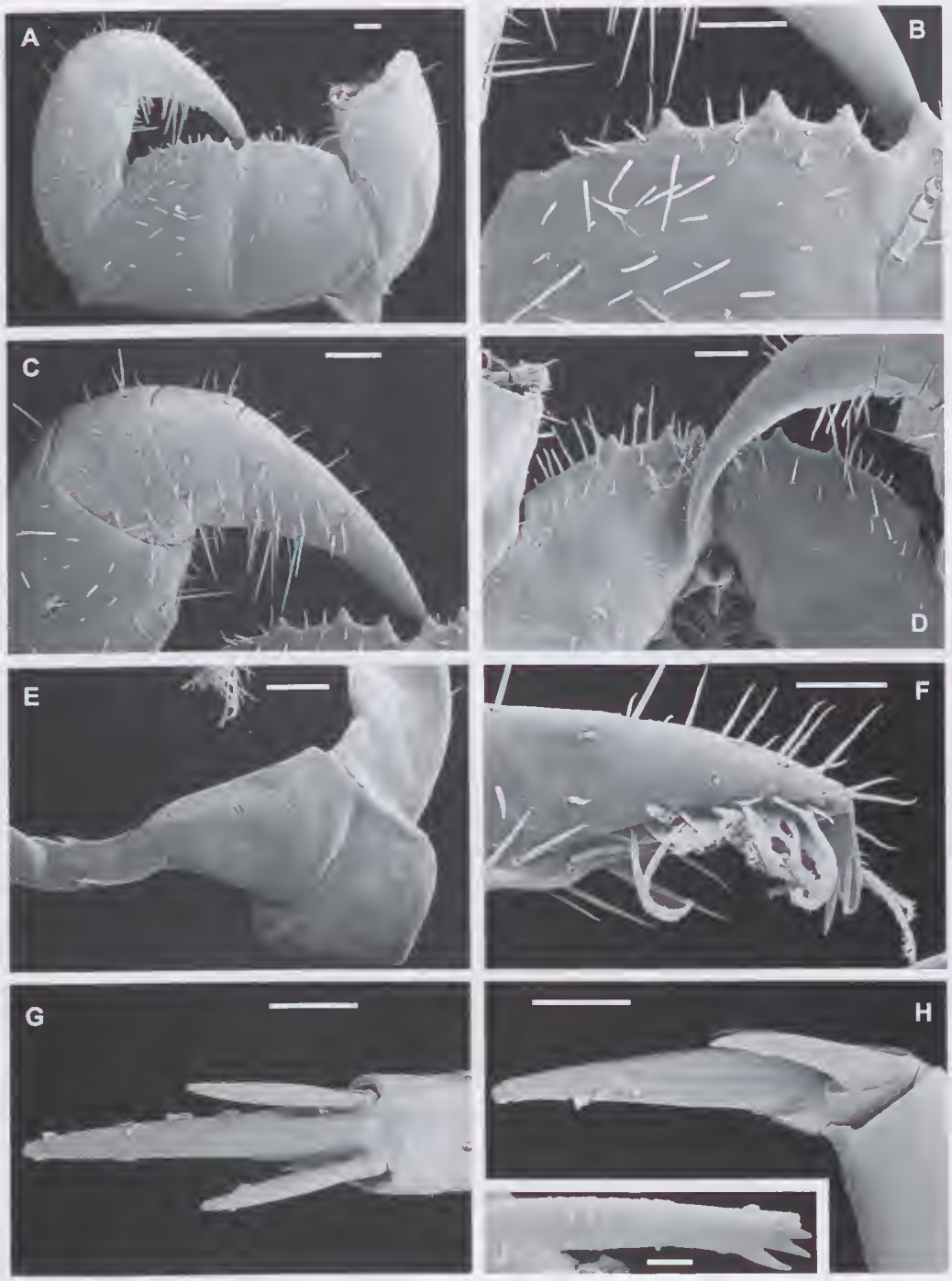

FIG. 5. *Easonobius tridentatus* gen. et sp. nov. SEMs, scales 100µm except F, 50µm, G-I1, 20µm, 1, 2µm. A-F, 1, QM S60291, ♀, Pic d'Amoa. A, ventral view of maxillipede; B, detail of dental margin of coxosternite; C, maxillipede telopodite; D, dorsal view of coxosternite; E, second maxilla; F, tarsus and claw of second maxilla; 1, distal part of lacinate seta on coxal process of first maxilla. G-H, AM KS 81365, ♀, Pic d'Amoa, dorsal and posterior views of claw, accessory claws and sensory spur of leg 14.

(Figs 2B-F, 3B, 4, 5A-F, I, 6), AM KS 81365. ♀ (Fig. 5G-H), from type locality, G.B. Monteith, 31 January 2002. OTHER MATERIAL. New Caledonia, leg. G.B. Monteith. PROVINCE NORD: QM S60292, ♂ (Fig. 3C), 21°11'S 165°18'E, Aoupinie, top camp, 850m, 2-4 November 2001. PROVINCE SUD: QM S60293, ♂, 21°45'S 166°00'E, Mt Do summit, 1000m, 21 November 2000.

DESCRIPTION. Length (head shield to end of telson, slightly extended specimen) up to 16mm; width of head shield up to 1.5mm. Colour (based on specimens in absolute ethanol): head shield orange with purple mottling, including region surrounding ocellus; antenna pale orange, sometimes with pale lavender tint along most of length; tergites lavender with deep purple longitudinal median band and mottling beside/on borders; sternites pale lavender except for orange sternites 14 and 15; legs pale yellow except for pale yellowish-orange tarsi.

Head shield. Wider than T1-T5, equally wide as T7, with shallow median notch, lacking longitudinal median furrow (Fig. 4A); maximal posterior extent of transverse suture at about 26% length of head shield; border as wide medially as posterolaterally. Ocellus large, moderately domed (Fig. 4A). Tömösváry organ relatively small (Fig. 4G), with outer margin near edge of cephalic pleurite, beneath ocellus (Fig. 4F).

Clypeus with cluster of about six apical setae (anterior pair and transverse band of three or four), several smaller setae scattered posterolateral to these (Fig. 4C); usual band of four setae just in front of labrum. Labral margin gently concave where cluster of bristles projects beyond margin; numerous branches along length of each bristle.

Antenna. 34-38% length of body, 3.7 times length of head shield in largest specimen (Fig. 3A); 31-27 and 31-31 articles in ♀♀, 30-30 and 31-30 in ♂♂; basal two articles much enlarged relative to others (Fig. 3A); articles 3-4, 7-8, 10-11 and one or two more distal pairs short. Terminal article up to 2.2 times length of penultimate; most of distal articles of similar shape, slightly wider than long (Fig. 4D). Setal density similar from third article, with mix of longer trichoid sensilla and shorter curved sensilla (Fig. 4B, E); most setae oriented normal to antennal surface or sloping anteriorly, arranged in imprecisely defined whorls, as many as seven whorls on longer articles.

Maxillipede. Dental margin gently convex, with 3+3 teeth; outer tooth more distant than inner pair to each other (Fig. 5B), well inside anterolateral corner of dental margin. Median notch moderately deep, parabolic or semicircular. Setae rather evenly scattered over anterior two-thirds of coxosternite (Fig. 5A); irregular band of short setae on anterior part of dorsal surface of coxosternite (Fig. 5D). Pretarsal part of tarsungulum about equal in length to tarsal part; long setae distinctly denser on inner side of tarsungulum than on outer (Fig. 5C); setation on tibia and femur fairly even on inner, outer and ventral sides.

Mandible. Four paired teeth (Fig. 6A). Eleven acicular, each with large, blunt pinnules approximately symmetrical on anterior and posterior margins (Fig. 6C-D). Fringe of branching bristles skirts acicular; ventral bristles with moderately wide bases, with even, rather dense branchings along entire length of each bristle (Fig. 6B); fairly abrupt transition to three overlapping rows of multifurcating scale-like bristles against second tooth; scales branch near their bases to form continuous fringe of slender, hair-like spines; fringe narrowing dorsally. Grooved ridges bearing row of blunt accessory denticles well developed on teeth (Fig. 6A-B); most accessory denticles small, triangular, even on dorsal tooth (Fig. 6E). Proximal part of dentate lamina consists of a narrow band of fused scales, strongly differentiated from furry pad (Fig. 6E); furry pad composed of simple and multifurcating bristles.

First maxilla. Coxal parts of coxosternum meeting along most of their length medially (Fig. 6F), separated posteriorly by small, wedge-shaped sternite. Coxal process with cluster of up to 15 simple setae at tip, a few setae along inner margin; four or five laciniate setae above simple setae near dorsal edge of coxal process (Fig. 6H), thicker than simple setae, branching into up to five short spines at their distal tips (Fig. 5I). Distal article of telopodite with two rows of up to 14 plumose setae along inner margin (Fig. 6G); plumose setal rows fringed along ventral side by row of shorter simple setae, along dorsal side on anterior half of article by row of slender spines, these more densely spaced than simple or plumose setae (Fig. 6G); ventral surface of distal article with numerous, evenly scattered simple setae.

Second maxilla. Sternite fused to coxa, margins distinct. Irregular band of about eight setae across anterior part of coxa (Fig. 5E). Joint between trochanter and prefemur defined as a notch along inner margin of telopodite (Fig. 5E). Inner face of tarsus with up to about 20 plumose setae, densely branching along their distal halves (Fig. 5F). Pretarsal claw small, composed of up to five

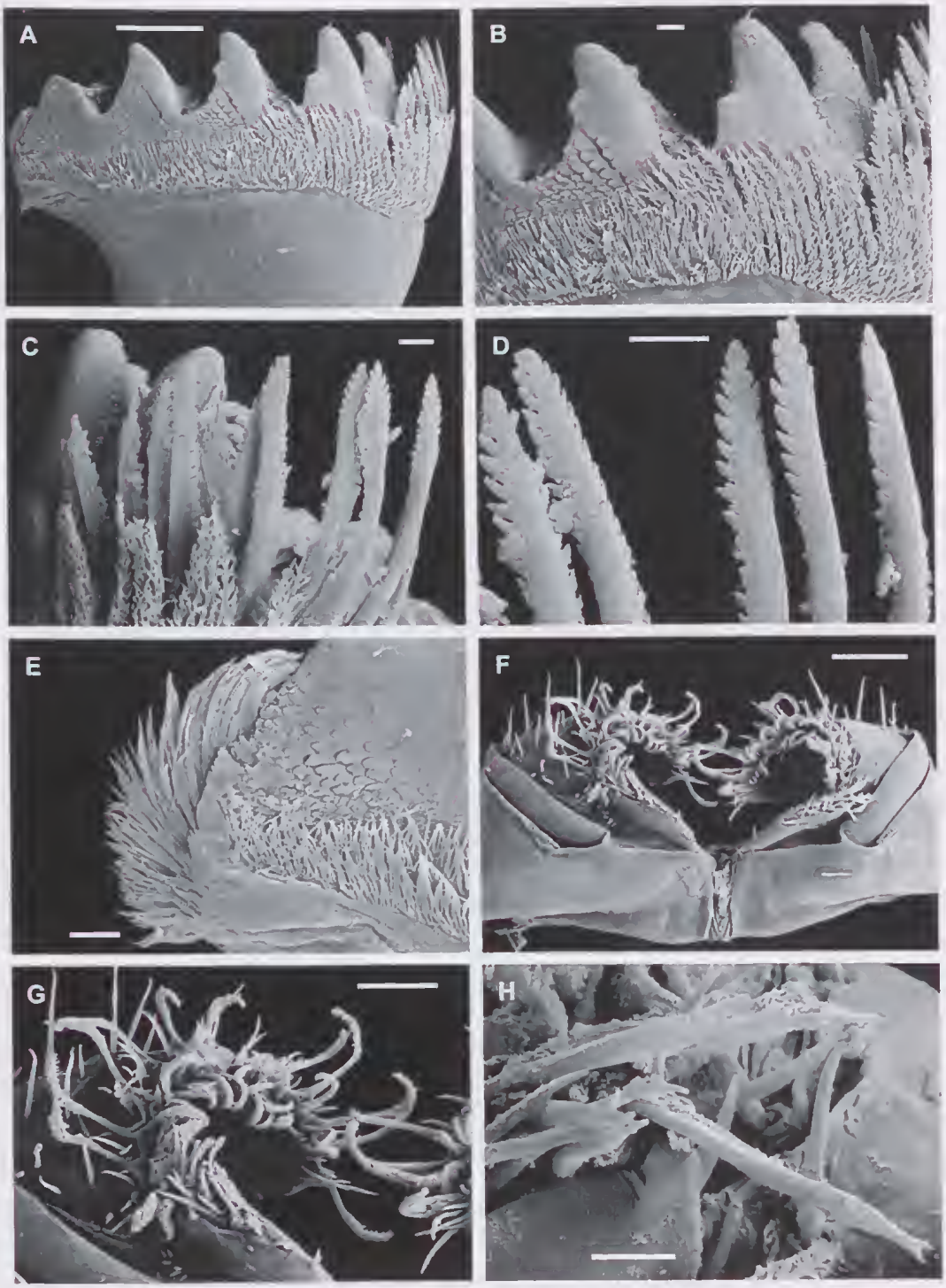

FIG. 6. *Easonobius tridentatus* gen. et sp. nov. SEMs. QM S60291, ♀, Pic d'Amoa. A-E, right mandible. A, gnathal lobe, scale 50µm; B, fringe of branching bristles and teeth, scale 10µm; C-D, aciculae, scales 10µm; E, furry pad, scale 10µm; F, first maxillae, scale 100µm; G, distal article of telopodite of first maxilla, scale 50µm; H, laciniate setae on coxal process of first maxilla, scale 10µm.

digits of varied length and thickness, median digit the largest (Fig. 5F).

Tergites (Fig. 3A).Weakly wrinkled, gently turned up against borders. T1 trapeziform, anterior width slightly less than T3, 81% width of widest tergite (T10), posterior margin transverse or faintly concave; posterior angles of TT1-5 rounded; lateral border subparallel in T3, posterior margin faintly or weakly concave; posterior margin of T5 distinctly concave, that of T8 slightly more so; TT9, 11 and 13 with strong, blunt projections and wide, transverse or convex median sector; T7 with shorter projections, median sector subtransverse or weakly convex; TT2, 4 and 6 bordered laterally, thickened posteromedially; TT10, 12 and especially 14 with concave posterior margins, blunt posterior angles. Tergite of intermediate segment with concave posterior margin in both sexes. Tergite of first genital segment less sclerotised than telson tergite. Short, spinule-like setae scattered across anterior third and laterally on long tergites; numerous short, spinule-like setae along lateral margins of tergites.

Legs. Distal spinose projection on tibiae of legs 1-13 (Fig. 2B, C), absent on 14 (Fig. 2D) and 15 (Fig. 2E). Legs 12-15 with length ratios 1: 1.2 : 1.6 : 2.5. Tarsal joints marked by desclerotised band and weak flexure on anterior legs, articulation weakly continuous on dorsal side of leg; distitarsus about 55% length of basitarsus on leg 12 (Fig. 2B), 63% length of basitarsus on leg 15; leg 15 basitarsus nine times longer than wide, distitarsus about 10 times longer than wide, tibia 5.5 times longer than wide (Fig. 2E). Prefemur with numerous short setae on dorsal and ventral sides, with one or a few longer setae near midlength on ventral side of legs 1-13; more evenly short setae on prefemur of legs 14-15; setae relatively fewer on femur and tibia, of similar size to most on prefemur, densest on tarsus; short setae on distitarsus of legs 1-14 sloping distally; setae relatively sparse on tibia and tarsus of leg 15. Anterior and posterior pretarsal accessory claws nearly symmetrical on all legs, about half length of main claw, weakly diverging (Fig. 5G); minute sensory spine on posterior side of claw base (Fig. 5H), lacking on anterior side.

Coxal pores. All round, separated by less than their diameter when abundant, inner pores smaller; 4,5,5,5/4,5,5,5 in largest ♀, 3,4,5,5/3,4,5,5 (Fig. 3B) and 2,3,4,4/2,3,4,4 in progressively smaller ♀♀; 3,3,4,3/3,3,3,3 in largest ♂, 1,2,2,2/1,2,2,2 in smaller ♂ (Fig. 3C); pore row not set in a groove, separated from anteroventral face of coxa by rounded surface.

Female (Fig. 3B). Sternite of segment 15 weakly to gently convex posteromedially, fringed with short setae along posterior margin. Setae fairly evenly scattered on posterior two-thirds of sternite of first genital segment, few or lacking on anterior third; transverse band of setae slightly in advance of posterior margin. Gonopod with two relatively small, conical spurs, inner spur slightly smaller; up to 20 setae on basal article of gonopod, up to 8 on second article, two or three on distal article; claw simple.

Male (Fig. 3C). Sternite of segment 15 weakly convex posteromedially, most setae along margins. Sternite of first genital segment undivided, a few setae in front of posterior margin. Articles of gonopod with four, two, and one small setae (proximally to distally).

DISCUSSION. Specimens assigned to *Easonobius tridentatus* sp. nov. resemble *E. humilis* (Ribaut) in having a similar number of antennal articles (27-31 in the new species versus 26-33 in *E. humilis*), projections with the same shape on tergites 9, 11 and 13, a bipartite tarsus on legs 1-12, and absence of a pseudoporodont. The holotype of *Easonobius humilis* is a small male (width of head 0.75mm; length of body 6.6mm) lacking most legs, and no other material was assigned to the species by Ribaut (1923). The original illustrations are accurate except for the position of the Tömösváry organ, which was depicted as anterior to the ocellus (Ribaut, 1923, fig. 24) when in fact the organ lies beneath the ocellus in the holotype and in new specimens assigned to the species, as is also the case in *E. tridentatus*. Ribaut noted 33 antennal articles in the description based on the right antenna; the unfigured left antenna has 30 articles.

All specimens of *Easonobius tridentatus* are larger than specimens of *E. humilis*, and all have 3+3 teeth on the dental margin of the maxillipede (Fig. 5A-D) versus 2+2 teeth on a narrower margin in *E. humilis* (Fig. 7A-B). Although some henicopids have an ontogenetic increase in number of maxillipede teeth [*Paralamyctes validus*: Archey, 1921: 182; *Anopsobius neozelanicus*: Archey, 1937: 87; *Paralamyctes* (*Haasiella*) *caminooensis*: Edgecombe, 2003b], tooth numbers in the *Lamyctes-Henicops* Group are fixed early in ontogeny when the adult number is 2+2 or 3+3 teeth. For example, the dental formula 3+3 is complete by 8-legged larval stadium LII in *Henicops* from Victoria,

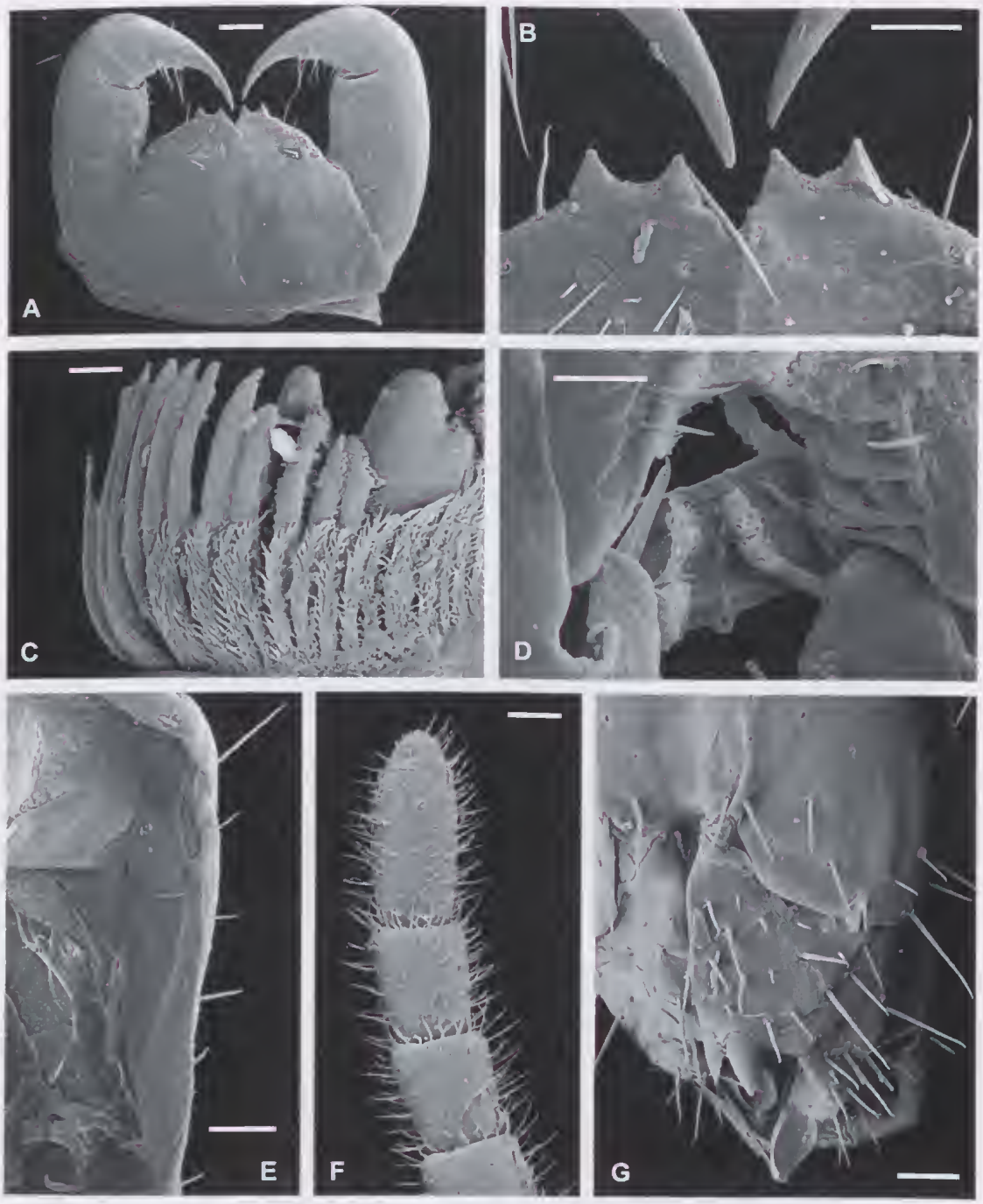

FIG. 7. *Easonobius humilis* (Ribaut, 1923). AM KS 81366, ♀, Mt Koghis. A, ventral view of maxillipede, scale 100μm; B, detail of dental margin of maxillipede coxosternite, scale 50μm; C, ventral part of mandibular gnathal edge, showing aciculae, scale 10μm; D, dorsal view of coxal processes of first maxillae and inner margins of telopodites, scale 20μm; E, cephalic pleurite, showing Tömösváry organ, scale 50μm; F, distal articles of antenna, scale 50μm; G, gonopods, scale 50μm.

Australia (Museum Victoria NOH-1778, 1782, 1786), and the coxosternite shape more closely resembles the adult shape than is the case between the much more similar sized specimens of *E. humilis* and *E. tridentatus*. *Lamyctes fulvicornis* (=*L. emarginatus*) likewise acquires its adult dental formula (2+ pseudoporodont) in LII, and the LII dental margin is similar to that of the mature stages (Andersson, 1984, fig. 6). The substantial differences between the coxosternal shape of *E. humilis* and the smallest specimens of *E. tridentatus* are thus unlikely to be attributable to ontogenetic change in a single species.

A few other differences between small (*E. humilis*) and larger (E. *tridentatus*) specimens are atypical for ontogenetic variation. The holotype of *E. humilis* and two additional specimens assigned to that species have a prominently rounded (convex) median sector to the posterior margin of T7, whereas this sector of the margin is at most weakly convex in *E. tridentatus*. Elaboration of tergal margins is typically enhanced, rather than suppressed, in lithobiomorph ontogeny (e.g., projections become more prominent: Andersson, 1981) so the modified margin of the small specimens appears to have taxonomic significance. The holotype of *E. humilis* and ♀ QM S60637 have a relatively longer antenna than do any specimens of *E. tridentatus*, the elongation deriving from a larger number of articles (maximum 33 in these specimens) and an elongation of the distal articles. The penultimate and adjacent articles in *E. humilis* are longer than wide (Fig. 7F), the reverse of the condition in *E. tridentatus* (Fig. 4D). The ♂ gonopod of the holotype of *E. humilis* (Ribaut, 1923, fig. 26) is more setose than is that of larger specimens of *E. tridentatus* (Fig. 3C).

Easonobius tridentatus (Fig. 4F) has a substantially smaller Tömösváry organ than does *E. humilis* (Fig. 7E). This difference may be size-related because several small Henicopidae have large Tömösváry organs; this is observed repeatedly in blind lineages [Anopsobiinae; *Lamyctes coeculus*; *Paralamyctes* (*Haasiella*) *trailli*] but also in some small species that retain ocelli [*P.* (*Haasiella*) *cammooensis* and *P.* (*H.*) *giniui*].

Modified setae on the coxal process of the first maxilla also serve to distinguish the species. *Easonobius tridentatus* has several lacinate setae near the dorsal margin of the coxal process, above the main cluster of simple setae (Figs. 5I), with branching confined to a few spines at the distal tip of the setae (Fig. 6H). In *E. humilis*, a single plumose seta (Fig. 7D) is instead present in addition to the simple setae.

Easonobius humilis (Ribaut, 1923)
(Fig. 7)

Paralamyctes humilis: Ribaut, 1923: 23, figs 24-26.
Paralamyctes humilis: Würmli, 1974: 526, fig. 2.
Analamyctes humilis: Chamberlin, 1955: 50.
Analamyctes humilis: Edgecombe, 2001: 206.

DIAGNOSIS. Wide head shield 0.75-0.8mm; penultimate and preceding few antennal articles longer than wide; dental margin of maxillipede coxosternite narrow, with 2+2 teeth, margin strongly sloping posterolaterally distal to outer tooth; Tömösváry organ large; single plumose seta near dorsal edge of coxal process of first maxilla; posteromedian embayment in margin of T7 convex; tergites lacking spinule-like setae.

MATERIAL. HOLOTYPE. Naturhistorisches Museum Basel, Zoologische Abteilung 303a, ♂, Oubatche, Province Nord, New Caledonia. OTHER MATERIAL. New Caledonia, leg. G.B. Monteith. PROVINCE SUD: AM KS 81366, ♀ (Fig. 7A-G), Mt Koghis, 22°11'S 166°01'E, 750m, 29 November 2000; AM KS 82627, ♂, Mt Koghis, 500m, 2-3 November 2002; QM S60637, ♀, S60651, ♀, Mt Humboldt, source, 21°53'S 166°24'E, 1300 m, 5-8 November 2002, rainforest.

DISCUSSION. Specimens from Mt Koghis (Fig. 7) and Mt Humboldt are assigned to *E. humilis* despite the substantial geographic distance from the type locality. The specific diagnosis indicates characters that these specimens share with each other to the exclusion of the larger *E. tridentatus*. The five specimens have a maximum number of 26, 28 (N=2) and 33 (N=2) antennal articles. The strength of tarsal articulations on anterior legs varies between specimens from the same locality (faint on Mt Humboldt specimen QM S60637 as in the holotype; well defined on Mt Humboldt specimen QM S60652). Coxal pore counts are 1,1,2,2/1,1,2,2 (holotype) and 1,2,2,2/0,2,2,2 (AM KS 82627) in males and 1,2,2,2/1,2,2,2 in females. The female gonopods (Fig. 7G) have a pair of bullet-shaped spurs with their bases adjacent to each other (see also Würmli, 1974).

PHYLOGENETIC RELATIONSHIPS

Morphological characters of *Easonobius humilis* and *E. tridentatus* are scored for the character set of Edgecombe (2003b). Several new characters (characters 52-57 in Table 1) bear on the relationships of *Henicops* and *Lamyctopristus*. Other than adding the two New Caledonian species, taxonomic sampling is as in

Edgecombe (2003b) except for the inclusion of *Lamyctopristus* (*Eumyctes*) *sinuatus* (Porat, 1893), as discussed above, and *Paralamyctes* (*Paralamyctes*) *asperulus* Silvestri, 1903 (=*P. tabulinus* Attems, 1928; see Edgecombe, 2003a). This species is included to test Chamberlin's (1955) concept of a New Caledonian/South African clade (his '*Capolamyctes*' concept).

Data were analysed with PAUP* version 4.0b10 (Swofford, 2002). A heuristic search used 5,000 random stepwise addition sequences that sampled five trees per iteration, followed by TBR (tree bisection-reconnection) branch swapping on these trees. Cladograms were rooted with Lithobiidae as outgroup to Henicopidae. Multistate characters were coded as unordered. Node support was evaluated via parsimony jackknifing (Farris et al., 1996). Jackknife frequencies were computed with PAUP* with 1000 replicates having 33% deletion. Each jackknife replicate involved a heuristic search with 20 random stepwise addition replicates and TBR branch swapping on 20 trees per replicate.

With the above analytical procedures, 4,233 shortest cladograms of 135 steps (Consistency Index 0.54; Retention Index 0.82; Rescaled Consistency Index 0.44) were found in all 5,000 replicates. Figure 8 depicts clades resolved in more than half of the jackknife replicates, indicating which of these groups are collapsed in the strict consensus. All clades with more than 50% jackknife support are present in all shortest cladograms.

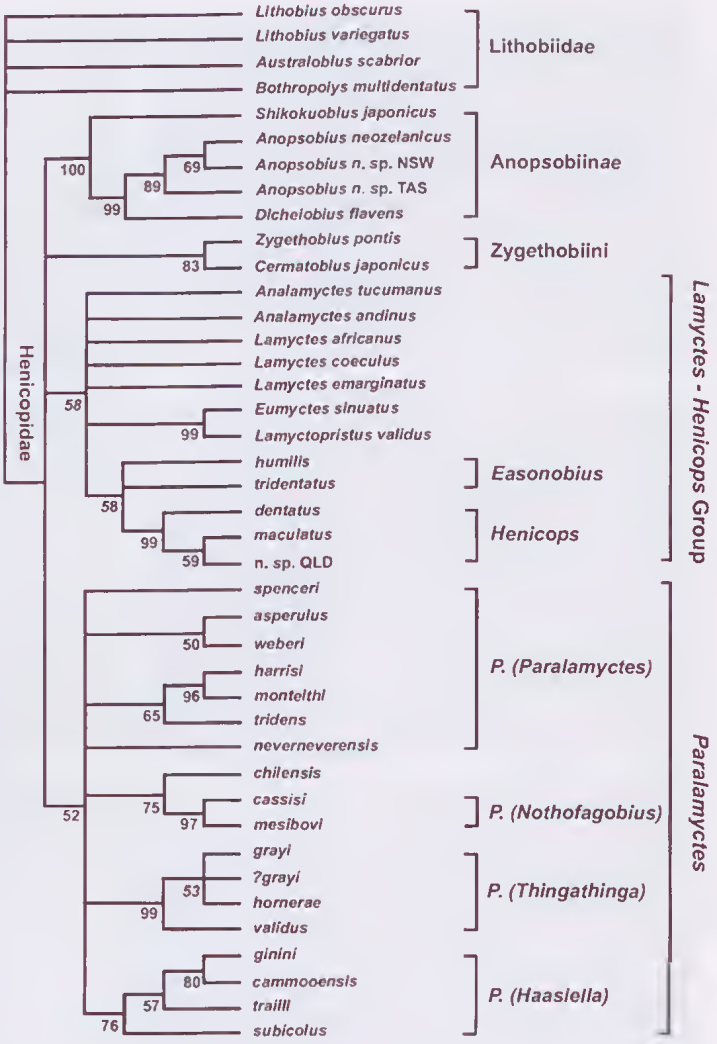

FIG. 8. Consensus of clades present in more than 50% of jackknife replicates based on morphological data in Table 2, showing jackknife frequencies. Groups with jackknife frequencies in italics are contradicted in some of the 4,233 minimal length cladograms.

A *Lamyctes-Henicops* Group is one of the most strongly supported clades in Henicopidae based on molecular data (Edgecombe et al., 2002; Edgecombe & Giribet, 2003b). This group, which includes the nominate genera together with *Analamyctes*, *Easonobius*, *Eumyctes* and *Lamyctopristus*, is supported in 78% of the shortest morphological cladograms, with a jackknife frequency of 58%. Apomorphies indicating membership of *Easonobius* in the *Lamyctes-Henicops* Group are the alternation of groups of short and long antennal articles (Fig. 4E) and an abrupt transition in the structure of the fringe of branching bristles on the mandible (characters 4:1 and 25:1, respectively). Within the group, only *Henicops* and a clade that unites *Eumyctes* and *Lamyctopristus* are present in all minimal length cladograms and have strong jackknife support (both 99%); the interrelationships of species assigned to *Lamyctes*,

TABLE 1. Morphological characters used in phylogenetic analysis (see Edgecombe et al., 2002; Edgecombe, 2003b, for descriptions and discussion of characters 1-51).

1. Ocelli: (0) cluster of ocelli; (1) single ocellus.

2. Convexity of ocellus: (0) bulging; (1) flattened.

3. Antennal segmentation: (0) 17 or more segments; (1) 15 segments.

4. Change in lengths of antennomeres: (0) gradual change in length along antenna; (1) markedly uneven in proximal part of antenna, with short, paired antennomeres interspersed between groups of longer ones.

5. Long, tubular antennomeres: (0) some antennomeres equally wide and long, proximal two antennomeres much larger than succeeding few; (1) all antennomeres longer than wide, proximal two antennomeres not substantially larger than succeeding few.

6. Tömösváry organ: (0) on small sclerotisation anteroventral to ocelli; (1) near margin of cephalic pleurite; (2) near midwidth of cephalic pleurite.

7. Tömösváry organ on margin of head: (0) organ on surface of cephalic pleurite; (1) organ in membranous field on margin of head.

8. Median furrow on head shield: (0) terminates in front of transverse suture; (1) deep and continuous to transverse suture.

9. Shoulder in labral margin: (0) absent; (1) present.

10. Pleurites of maxillipede segment connected ventrally, forming a continuous band between maxillipede coxosternite and sternite of first pedigerous segment: (0) pleurites discontinuous; (1) pleurites continuous.

11. Shape of maxillipede coxosternite: (0) subtriangular coxosternite with narrow, curved dental margin; (1) subtrapezoidal coxosternite with narrow, straight dental margin; (2) narrow dental margin, markedly V-shaped, with deep median notch; (3) subsemicircular coxosternite with wide, convex dental margin; (4) trapezoidal coxosternite with narrow, curved dental margin; (5) wide, subtransverse dental margin; (6) narrow, straight dental margin projected forward; (7) trapezoidal coxosternite with moderately wide, weakly V-shaped dental margin.

12. Paired cusps on teeth on maxillipede coxosternite: (0) absent (unpaired, conical teeth); (1) present.

13. Porodont: (0) absent; (1) translucent, seta-like porodont; (2) conical, tooth-like pseudoporodont.

14. Proportions of maxillipede tarsungulum: (0) pretarsal section of approximately equal length to tarsal section; (1) pretarsal section much longer than tarsal section.

15. Dense setation on inner part of maxillipede tibia and femur: (0) absent; (1) present.

16. Body narrowed across anterior part of trunk: (0) T1 of similar width to head and T3; (1) T1 markedly narrower than head and T3.

17. Angulation (projections) of posterolateral corners of tergites: (0) some angular or toothed; (1) all rounded.

18. Posterior margin of tergite 7 embayed, with median sector straight and thickened ventrally: (0) absent; (1) present.

19. Course of posterior margin of tergite 8: (0) concave; (1) transverse.

20. Spiracle on first pedigerous trunk segment: (0) absent; (1) present.

21. Row of digitiform pinnules with pointed tips along dorsal edge of aciculae: (0) absent; (1) present.

22. Entire acicula series simple: (0) absent; (1) present.

23. Fringe of branching bristles on mandible: (0) extends along entire gnathal margin, skirting aciculae; (1) terminates at aciculae.

24. Ventral bristles in fringe on mandible with a wide base: (0) absent; (1) present.

25. Differentiation of branching bristles on mandible: (0) branching structure of bristles grades evenly along fringe; (1) abrupt transition between rows of scale-like bristles and single row of plumose bristles.

26. Width of fringe of branching bristles dorsally: (0) fringe narrowed dorsally, not developed along all bristles of furry pad; (1) fringe wide, dense, developed along whole length of furry pad.

27. Accessory denticles on mandible all triangular, continuous between teeth, without grooved ridges on teeth: (0) absent; (1) present.

28. Furry pad intergrades with accessory denticles: (0) absent; (1) present.

29. Shape of first maxillary sternite: (0) small, wedge-shaped, with median suture; (1) large, bell-shaped, coxae not merged anterior to sternite, suture between coxa and sternite confined to posterior edge of maxilla.

30. Basal joint of telopodite of first maxilla fused on inner side to coxal process: (0) telopodite distinctly demarcated; (1) telopodite fused to adjacent part of coxa.

31. Setae on coxal process of first maxilla: (0) dense cluster of differentiated setae; (1) simple setae; (2) laciniate setae or plumose amidst simple setae.

32. Coxa of leg 15 with long, lobate process ending in a spine: (0) absent; (1) present.

33. Prefemur of leg 15 with spurs: (0) spurs absent; (1) single ventral spur; (2) several spurs in a whorl.

34. Coxal pores: (0) on legs 14 and 15 only; (1) on legs 13-15 only; (2) on legs 12-15 only; (3) on legs 11-15.

35. Coxal pores set in deep groove, largely concealed by anteroventral face of coxa in ventral view: (0) absent; (1) present.

36. Distal spinose projections on tibiae of legs 1-11: (0) absent; (1) present.

37. Distribution of distal spinose projections on tibiae: (0) strong projection on legs 1-11 only (weak projection variably distinct on leg 12); (1) strong projection on legs 1-12 only; (2) strong projection on legs 1-13 only; (3) strong projection on legs 1-14 only; (4) strong projection on legs 1-15.

38. Tarsus of legs 1-12: (0) divided into basitarsus and distitarsus; (1) undivided.

39. Articulation between basitarsus and distitarsus on anterior pairs of legs: (0) distinct on dorsal side of leg; (1) fused on dorsal side of leg, distinct ventrally.

40. Subdivision of basitarsus indicated by paired larger setae: (0) absent; (1) present.

41. First tarsal segment of legs 1-12 bisegmented (tripartite tarsus): (0) absent; (1) present.

42. Accessory apical claws: (0) anterior and posterior accessory claws; (1) posterior accessory claw only. Supposed absence of an anterior accessory claw in *Lamyctopristus validus* (Edgecumbe, 2003b) is in error. A leg associated with the holotype has an anterior and posterior accessory claw.

43. First genital sternite of ♂ divided longitudinally into two sclerites: (0) undivided; (1) divided.

44. Segmentation of ♂ gonopod: (0) four segments with a seta-like terminal process; (1) stout gonopod with one or two segments.

45. Number of spurs on ♀ gonopod: (0) two; (1) three; (2) five to seven.

46. First article of ♀ gonopod extended as a short process: (0) absent; (1) present.

47. Claw of ♀ gonopod: (0) simple (unipartite); (1) tripartite, dorsal and ventral accessory denticles present.

48. Tömösváry organ large, positioned posteriorly on pleurite: (0) absent; (1) present.

49. Maxillipede teeth progressively decreasing in size and spacing medially: (0) absent; (1) present.

50. Aciculae differentiated into two (outer and inner) rows: (0) absent (single row of aciculae); (1) present.

51. Accessory denticles on dorsal part of mandible: (0) simple, triangular accessory denticles; (1) flattened, multifurcating scales; (2) tuberculate scales.

52. Tergal tuberculation: (0) absent or faint; (1) strong, more pronounced in ♂♂ than ♀♀.

53. Distitarsus of leg 15 divided: (0) undivided (single tarsomere); (1) divided into two or more tarsomeres.

54. Curvature of distitarsal part of leg: (0) straight; (1) curved.

55. Insertion of anterior pretarsal accessory claw: (0) on dorsolateral side of main claw; (1) on ventrolateral side of main claw. Most henicopids have the anterior and posterior accessory claws originating dorsolaterally on the main claw (Fig. 5I1 for *Easonobius tridentatus*; Fig. 1G for *Henicops maculatus*). Some species of *Paralamyctes* (*Paralamyctes*) (Fig. 1H) and *Eumyctes sinuatus* (Fig. 1F) have the anterior accessory claw originating near the ventral margin of the main claw.

56. Definition of scutes on pretarsal accessory claws: (0) absent or weak; (1) strong (Edgecombe & Giribet, 2003a: character 57).

57. Definition of scutes on proximodorsal part of main pretarsal claw: (0) distinct; (1) indistinct (Edgecombe & Giribet, 2003a: character 58).

TABLE 2. Codings for 57 morphological characters listed in Table 1.

Lithobius obscurus	0-0000-000 0011000000 0000000000 002200-000 0101001000 0000-00
Lithobius variegatus rubriceps	0-0000-000 7011000000 0000000000 002200-000 0101000000 0000-00
Australobius scabriar	0-0000-000 7010000000 0000000000 002200-000 0101101000 0000-00
Bothropolys multidentatus	0-0010-000 2011000000 0000000000 002200-000 0101001000 0000-00
Shikakuobius japonicus	--00010001 0010001010 0010010000 11120101-0 0000000000 2000000
Dichelabius flavens	--00010101 2010001010 0010010000 11100101-0 0000010000 2000001
Anopsobius neozelanicus	--10010101 2110001000 0010010000 11100111-0 0000010000 2000001
Anopsobius sp. nov. NSW	--10010101 2110001010 0010010000 11100111-0 0000010000 2000001
Anopsobius sp. nov. TAS	--10010101 2010001010 0010010000 11100111-0 0000010000 2000001
Zygethobius pontis	1000010001 3000000100 0010010101 1003113000 0000000000 0000000
Cermatobius japonicus	1100010001 3001000100 0000010111 1002112070 0000100000 0011000
Lamyctes emarginatus	1001010001 0020001001 0001000001 10020101-0 0000000000 1000000
Lamyctes africanus	1001010001 0020001001 0001000001 10020111-0 0010000000 1000000
Lamyctes caeculus	--00010001 0020001001 0001000001 10020101-0 00??000100 1000000
Lamyctapristus validus	1001010001 0021000001 000??00001 10020131-0 0000200001 ?1011??
Lamyctopristus (Eumyctes) sinuatus	1001010001 0001000001 0001000001 10020131-0 0000000001 0101100
Henicops maculatus	1001020001 1000000001 0001000001 2002013011 1010000001 0010000
Henicops dentatus	1000010001 1000000101 0001000001 2002013011 1010000001 0010000
Henicops sp. nov. QLD	1001020001 1000000001 0001000001 2002013011 0010000001 0010000
Analamyctes tucumanus	1001010001 0000001001 0001000001 1002012000 0000000000 0000000
Analamyctes andinus	1001010001 0020001001 0001000001 1002013000 0000000000 1000000
Paralamyctes (Paralamyctes) spenceri	1000010101 4001000001 1000000111 1002012000 0000000000 0000000
Paralamyctes (Paralamyctes) asperulus	1000010101 4001000101 1000000111 1002012000 0000000000 0000100
Paralamyctes (Paralamyctes) weberi	1000010101 4001000001 1000000111 1002013000 0000000000 0000100
Paralamyctes (Paralamyctes) tridens	1000011101 3001000001 1000000111 1002012000 0000000000 0000000
Paralamyctes (Paralamyctes) manteitbi	1000111111 3001100001 1000000111 1002013000 0000000000 0000100
Paralamyctes (Paralamyctes) harrisi	1000111111 3001100001 1000000111 1002013000 0000000000 0000000
Paralamyctes (Paralamyctes) neverneverensis	1000010101 4000000001 1000000111 1002014000 0000000000 0000000
Paralamyctes chilensis	1000010101 4000010001 0000000011 1002013000 0000010000 0000000
Paralamyctes (Nothofagobius) cassisi	1000010101 4000010001 0100001011 1002014000 0000110000 0000000
Paralamyctes (Nothofagobius) mesibovi	1000010101 4000010001 0100001011 1002014000 0000110000 0000000
Paralamyctes (Thingathinga) grayi	1100010111 5001000101 0100000011 1002113010 0000000000 0000011
Paralamyctes (Thingathinga) ?grayi	1100010111 5001000101 0100000011 1002014010 0000000000 0000011
Paralamyctes (Thingathinga) hornerae	1100010111 5001000101 0100000011 10?201?010 0000000000 0000011
Paralamyctes (Thingathinga) validus	1000010111 5001000001 0100100011 1002114010 0000000000 0000011
Paralamyctes (Haasiella) trailli	--00010101 6001000011 0000000011 10020121-0 0000000110 0000000
Paralamyctes (Haasiella) subicolus	1100010101 5001000011 0000000011 10020131-0 0000000010 0000000
Paralamyctes (Haasiella) cammooensis	1100010101 4000001011 0000000011 10020111-0 0000000110 0000000
Paralamyctes (Haasiella) ginini	1100010101 4000001011 0000000011 10020111-0 0000000100 0000000
Easonobius humilis	1001010001 0000000101 0001000001 20?2012000 0000000000 00?0000
Easonobius tridentatus	1001010001 1000000101 0001000001 2002012000 0000000000 0000000

Analamyctes and *Easonobius* are labile. Amongst the minimal length cladograms, the two species assigned to *Easonobius* have three alternative resolutions: monophyletic sister group of *Henicops*, monophyletic sister group of *Analamyctes tucumanus*, or paraphyletic with *E. tridentatus* being closer to *Henicops* than is *E. humilis*.

Parsimony jackknifing favours a closer relationship between *Easonobius* and *Henicops* than with *Analamyctes*, the former grouping having a jackknife frequency of 58%.

Easonobius tridentatus in particular shares its shape of the maxillipede coxosternite (character 11:1) with *Henicops*, closely resembling species such as *Henicops dentatus* in having a gently convex dental margin with the outermost (third) tooth set well inward of the anterolateral corner (Fig. 5A, B). The coxosternal shape in *E. humilis* (Fig. 7A) is instead more similar to that of *Analamyctes*, *Lamyctopristus* and *Lamyctes* (character 11:0), and in some shortest cladograms the similarity between *E. tridentatus* and *Henicops* is a synapomorphy. A cluster of lacinate setae amidst the simple setae on the coxal process of the first maxilla (character 31:2) is also shared by *Easonobius* (Fig. 6H) and all species of *Henicops*. A similarly positioned group of three laciniate setae was described by Ribaut (1923, and Ribaut's unpublished drawings of the holotype) in another New Caledonian species, *Lamyctes brevilabiatus* Ribaut, 1923. Molecular sequence data suggest that '*Lamyctes*' *brevilabiatus* is nested within *Henicops* as the latter is traditionally delimited (Edgecombe & Giribet, 2003b). This species is excluded from *Easonobius* based on its indistinctly jointed tarsi on legs 1-12, unprojected tergites (e.g., transverse posterior margins of TT11 and 13), and bipartite first genital sternite in the male. It is further distinguished at the species level from both known members of *Easonobius* by its more segmented antenna (38-47 articles in QM S60636, S60651, AM KS 82580, KS 82626) and extreme proximity of the inner two teeth on the maxillipede coxosternite (distance between outer and middle teeth about 2.5 times that between middle and inner tooth).

Alternative relationships for *Henicops* are favoured in some of the shortest cladograms. In particular, *Henicops* and *Lamyctopristus* (including *Eumyctes*) sometimes unite to the exclusion of *Easonobius*, with this resolution being supported by a distal spinose projection on the tibia of leg 14 (character 37:3) and mandibular aciculae differentiated into two rows (character 50:1).

Turning to Chamberlin's (1955) hypothesis that *Easonobius humilis* is especially closely related to South African species, an exemplar of the latter group, *Paralamyctes asperulus*, nests in a monophyletic *Paralamyctes* and, in most minimal length cladograms, in *P.* (*Paralamyctes*). That clade is defined by two unique mandibular characters (characters 21:1 and 28:1) as well as molecular synapomorphies (Edgecombe et al., 2002; Edgecombe & Giribet, 2003a). The classification of this and allied South African *Paralamyctes* with *Easonobius humilis* based on a single, highly homoplastic antennal character (Chamberlin, 1955), is emphatically rejected. The classification of Ribaut (1923), in which *E. humilis* was assigned to *Paralamyctes* based on its bipartite tarsi on all legs (character 38:0), is opposed by the absence of a complete median furrow on the head shield (character 8:0; Fig. 4A) and a reduced, rather than bell-shaped, first maxillary sternite (character 29:0; Fig. 6F). The apomorphic homologues unite *Paralamyctes* (Edgecombe, 2001).

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NOTE ADDED IN PROOF

Anopsobius n. sp. NSW (Fig. 8, Table 2) has been formalised as *Anopsobius wrighti* Edgecombe, 2003e.

GREAT ARTESIAN BASIN SPRINGS IN SOUTHERN QUEENSLAND 1911-2000

RUSSELL J. FAIRFAX AND RODERICK J. FENSHAM

Fairfax, R.J. & Fensham, R.J. 2003 06 30: Great Artesian Basin springs in Southern Queensland 1911-2000. *Memoirs of the Queensland Museum* 49(1): 285-293. Brisbane. ISSN 0079-8835.

This study presents descriptions of Great Artesian Basin springs in south-central Queensland from 1911-1912. It compares these records with a second survey conducted in 1999-2000. Of 58 springs documented in the initial survey, 42 were inactive and 13 active in the year 2000. Three were not re-located. Observations concerning fluctuations in spring flows, causes of spring inactivity and wetland vegetation are provided. ❐ *Great Artesian Basin, bores, springs, Queensland, history.*

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The Great Artesian Basin (GAB) lies beneath much of the semi-arid land in northeastern Australia (Fig. 1) and is the continent's most voluminous aquifer. The Basin is charged by rainfall that enters porous sedimentary sandstones outcropping along the Great Dividing Range (Habermehl, 1982; 2001). Water naturally exits the aquifer within these recharge areas as 'recharge-rejection springs' and as 'discharge springs' on the lower, inland margins of the basin where the age of the water may exceed 800,000 years (Radke et al., 2000). GAB springs are regionally clustered and referred to as spring Super-groups (Fig. 1). For the purposes of presentation the term Spring-group is used to represent multiple vents/springs where no adjacent pair of springs is more than about 1km distant. Spring-groups are often referred to by the place name 'Springs' e.g. Baroona Springs. 545 Spring-groups have been documented from Queensland (Fensham & Fairfax, in press).

Individual GAB springs have been recorded as discharging a few to several million litres of water per day (Habermehl, 1998; Fensham & Fairfax, in press), corresponding to muddy areas of a few square metres to permanently flowing streams. Many of the wetlands contain flora and fauna endemic to GAB springs, notably fish, plants, snails and other invertebrates. Some species such as the Elizabeth springs Goby (*Chlamydogobius micropterus*) have only been recorded from one isolated Spring-group and numerous other endemic species are limited locally or regionally (e.g. Ponder & Clark, 1990; Ponder, 1986). Some springs are conspicuously mounded (to 6m high) due to the accumulation of discharged-mineral matter. Such mud springs generally do not support vegetated wetlands and in Queensland are most common in the Eulo Super-group.

Artesian bores first tapped the GAB in the late 1870's. Since then over 5,000 flowing bores have been sunk: the pressure within the Basin has dropped and currently about half of the bores still flow. Directly related to this reduction in artesian pressure (referred to as 'draw-down') about two-thirds of Queensland springs in the discharge areas no longer flow (Fensham & Fairfax, in press).

The Queensland portions of the Eulo and Bourke spring Super-groups form the current study area (Fig. 1). The region can be considered as semi-arid, with an average mean annual rainfall at Eulo in the order of 332mm/yr (Clewett et al., 1994). These Super-groups lie within the Warrego GAB Hydrologic Zone in which the average pressure head has decreased by 39m (range 0-120m) since development of the GAB (GABCC, 1998). This zone has the greatest loss of pressure within the GAB. Springs from the Eulo Super-group currently discharge about a third of their early 20th Century output of 1.6ML/day, 62% of 116 Spring-groups have become completely inactive and a further 14% partially inactive (Fensham & Fairfax, in press). That study found no inactive springs from the Queensland portion of the Bourke Super-group, although Pickard (1992) reports that 15 of 45 springs were extinct from the NSW portion.

Three of the four GAB spring endemic plants in Queensland (*Myriophyllum artesium*, *Sporobolus pamelae* and *Eragrostis* sp. RJ Fensham 3705) were recorded from the Eulo Super-group in 1999/2000. The endangered salt

pipewort *Eriocaulon carsonii* was recorded from this area (Queensland Herbarium, unpubl. data) as well as from one spring in the NSW portion of the Bourke Super-group (Pickard, 1992). Several species of GAB endemic snails and isopods have also been recorded from Eulo springs (W. Ponder, pers. comm.).

The dramatic decline in spring flows and threatened GAB spring-dependent fauna and flora confer great conservation value upon remaining springs. The biggest threat to the water source, i.e. draw-down of the aquifer, is being addressed by a program to cap remaining flowing bores and improve the efficiency of water use (e.g. GABCC, 1998). In some areas where this has happened there are signs that the output of both springs (Fensham & Fairfax, in press) and bores (GABCC, 1998) has increased. Opportunities to rehabilitate springs (e.g. revegetation) may present themselves in the future. However, our knowledge of spring wetlands prior to their demise is poor and unrecorded. One written historical source is the reports of artesian bore inspectors in the late 19th and early 20th Centuries. Although focusing on the condition and output of bores these surveyors also briefly described the physical characteristics of springs (e.g. size and flows) and modifications (e.g. wells and bores) made to them (Fairfax & Fensham, 2002). Such descriptions enable a comparison between past and present, and provide a benchmark for which spring recovery can be gauged.

This article summarises various aspects of springs described within a survey of artesian bores and springs conducted in 1911-1912. Descriptions from that survey are compared with another field survey conducted by the authors in February 1999 and August 2000, in which a spring was considered active if it was wet at the ground surface or wobbled when jumped upon. A spring was also considered active in the case of wells when water was visible regardless of depth below ground surface. Thus our definition of 'active' does not imply that the spring maintains a natural wetland. Limitations and insights of the original survey information and changes in spring activity over the last century are discussed. The current activity of these springs has been collated within the broader study of Fensham & Fairfax (in press).

THE 1911-12 SURVEY

The first survey was conducted by C. Ogilvie and E. Edwards between October 1911 and April 1912, and documented within the handwritten,

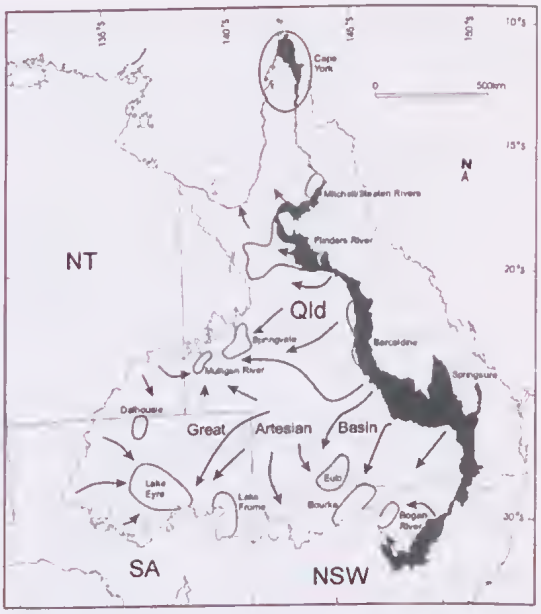

FIG. 1. Map of the GAB based upon Habermehl & Lau (1997). The shaded pattern represents the recharge area; arrows represent modeled flow lines after Welsh (2000). Dashed lines represent spring Super-groups adapted from Habermehl (1982).

unpublished Artesian Reports Volumes VIII, IX and XVI held by the Queensland State Archives (reference numbers RSI 3037-1-8, 9 and 16). Within these reports the locations of most springs are either described or mapped with sufficient detail to enable their relocation.

Ogilvie & Edwards' 1911-12 survey recorded 56 separate springs (at least 48 Spring-groups) within the Eulo Super-group (Fig. 2; Table 1). Six of these were not surveyed as they were considered 'unimportant'. It can be assumed that these springs were dry or had particularly negligible flows. The descriptions of three groups suggest they were completely dry and may have been inactive prior to the first artesian bores in the district (1890's). Flows (gallons per day) were estimated for 22 springs. The survey was not comprehensive, as a further 68 Spring-groups were located for that district from other historical sources and field surveys during 1999 and 2000 (Fensham & Fairfax, in press). Ogilvie and Edwards also described two Spring-groups within the Bourke Super-group, approximately 200km east of the Eulo springs (Fig. 2; Table 1).

The descriptions were concise and largely restricted to the nature of modifications made to the springs to facilitate either greater flows or

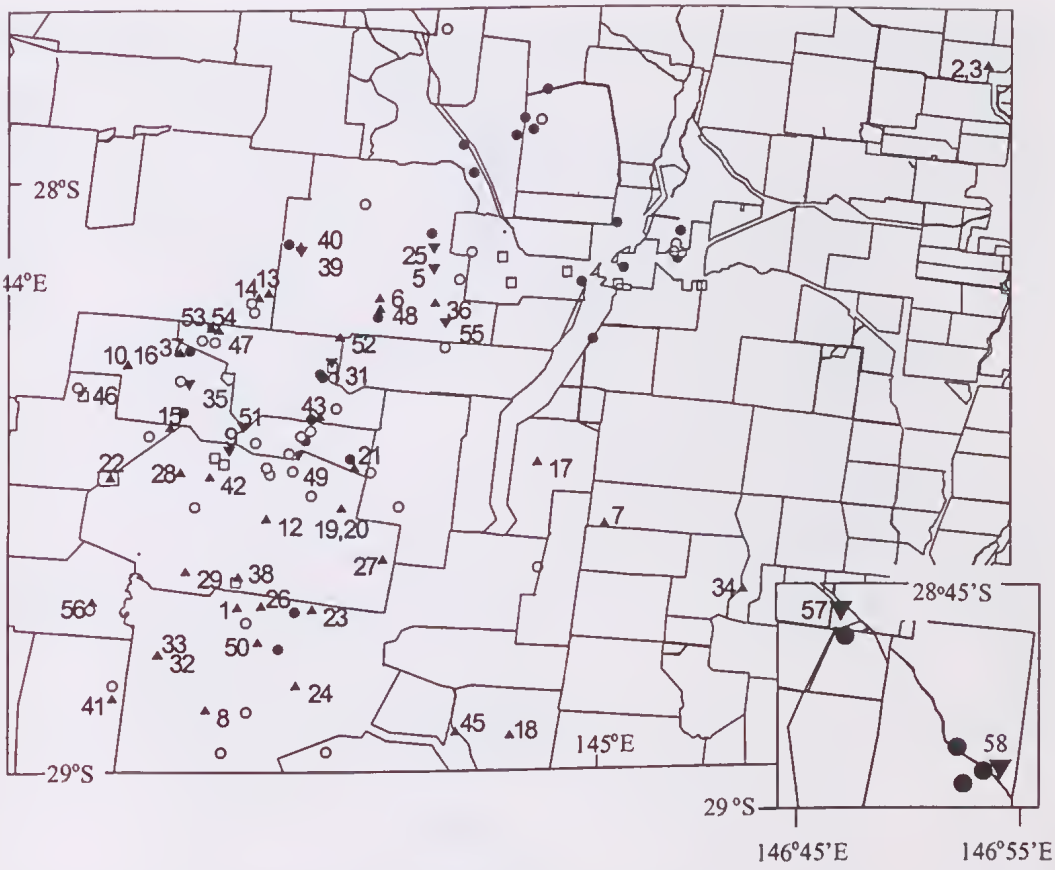

FIG. 2. Map of the Eulo district showing springs active in 1912 and 2000 (▼); active in 1912 and inactive 2000 (▲); other inactive Spring-groups 2000 (○); other active Spring-groups 2000 (●), and Spring-groups in 2000 containing both active and inactive springs (□). The latter 3 categories comprise springs not surveyed during 1911-12. Numbers correspond to springs listed in Table 1. Approximate current property boundaries are shown. The inset portrays springs within the Bourke Super-group. All springs represent Spring-groups except 2 and 3, 10 and 16, 19 and 20, and 53 and 54.

access to clean water. Indeed, it was mainly those springs with improvements that were visited and described; springs that could not be made to yield useful amounts of water were considered unimportant and generally not visited (Table 1). No mention was made of evidence of use of springs by Aboriginals (Robins, 1998) or native fauna associated with the springs. However, incidental notes included observations on fluctuations in spring flows, causes of some spring inactivity and broad botanical references (Table 1).

DISCUSSION

The work of Ogilvie and Edwards provides the earliest known benchmark from which GAB springs of southern Queensland can be assessed. At least three of the 56 springs documented from the Eulo Super-group were inactive when this survey was conducted around 1912. Following re-survey in 1999-2000, 42 (75%) had become inactive and 11 remained active to some extent. Three springs were unlocated in 1999- 2000 because their locations were not described in the original survey. Although not all springs within the Eulo Super-group were documented in 1911-12, the level of spring extinction revealed by this study is similar to the more comprehensive survey of that Super-group by Fensham & Fairfax (in press): 24% of Spring-groups active, 62% inactive, and 14% with both active and inactive springs. The two Spring-groups

TABLE 1. Summary of spring descriptions, use, flows, modifications made to them by 1912 and water taste. Bore flows were sourced from Dunstan (1913). gpd=gallons per day (1 gallon = 4.536L). A=active, X=inactive.

Spring(S) Name	No.	Abridged Spring Deseription	Human Use, Quality to Taste (1911-1912)	Flow (Gpd)	Developments	1999-2000 Status
Eulo Supergroup						
Barb	1	Several aeres containing a number of dry mounds				X
Baroona (1)	2	One large flowing and several smaller non-flowing vegetated peaty springs; clumps of tall rushes, miranda (Typha spp.) 'Rankin [the lessee] says the flow seems to slacken during summer, but this is rather doubtful evidence as the total overflow is only about 500 gpd and this could readily be evaporated from the damp ground surrounding the well and consequently not reach the claypan about 30 yards distant.' 'The springs are stated to be independent of local rainfall for several years at least.' '…this spring watered about 4000 cattle during a drought in the early days of Tinnenburra Run but this is eertainly excessive as its maximum flow at the bottom of the well is only 4110 g.p.d…'	Cooks Galley, Shearer's Hut; fair	4610	Well, pump, troughing	X
Baroona (2)	3	A few overflowing and about a dozen smaller vegetated springs; whole surface thickly coated with duckweed, mosses, rushes and other vegetation		1000	Pump	X
Bingara (old HS)	4	A single mud spring	Travelling public; good			X
Bingara (HS)	5	Four small improved springs and two large wet non-flowing mounds	Homestead; good	500	Wells	A
Bingara Springs	6	30-40 acres of dry mounds and wet mud springs		Small	Bore (40,000 gpd), unspecified improvements	X
Bitherty	7	1 dry and 1 wet mud spring with no evidenee of recent overflow. An Acacia bush locally regarded as a sign of subterranean water present		Exceptionally large	Well	X
Bokeen	8	Unspecified, 'unimportant'	Outstation, boundary riders; good		Well, pump, troughing	X
Boomerang	9	Unspecified, 'unimportant'				A
Unnamed (Boorara)	10	A group of mounds up to 18 foot high praetieally all dry				X
Boorara	11	Seattered group of dry mounds 4-6 feet high		small		?
Boorara Woolshed	12	Single wet mud spring	Woolshed		Well, bore (17,000 gpd)	X
Bullenbilla (1)	13	About 20 mud mounds all wet at the surface, 6 overflow slightly and form small patches of green feed		500	Bores	X
Bullenbilla (2)	14	5 very large mounds (1 wet at surface) and 2 small carpet springs		5	Excavated	X
Burtanya	15	Unspecified, 'unimportant'				X
Bush	16	2 main improved springs and several smaller, one of which supplies a pool 10 foot diameter by 6 inches deep; very dense clump of reeds at troughs			Two wells, troughing, bore that yielded 9,000 gpd in 1901; dry by 1913	X
Caiwarro Mud	17	'When visited none of the springs were actually flowing, although 7 mounds were wet and boggy. There are altogether about 13 mounds, the biggest of which is about 8 ft high and not running. I am led to believe that the springs occasionally overflow, but there is no regularity in the periods of diseharge'.				X
Caiwarro Bore	18	Small mud spring			Bore (25,000 gpd)	X
Colanya bore	19	Small spring			Bore (75,000 gpd in 1913; 90,000 in 1901)	X

TABLE 1 (*Cont.*)

Colanya springs	20	1½ miles of mounds to 15 feet high, some are wet and overflow, a few permanent holes; wells overgrown inside and out with reeds	Good	1600	3 wells, troughing	X
Corina	21	150-200 mostly dry mounds (extending about 2 miles) 5-20 feet high		200	Reservoir, troughing	X
Curracunya	22	A few acres of boggy flat, springs do not overflow to any extent	Homestead, pub		Well	X
Currawinya	23	A few mounds scattered within 1 mile diameter, 1 overflows slightly			Tank	X
Currawinya Station	24	Unspecified; possibly containing a small bamboo (Phragmites australis)	Homestead; excellent	600	Well	X
Dewalla	25	2 large (the main spring discharges into a grassy bog 1 chain wide), some smaller mud springs free of growth & several dry mounds	Travelling public; excellent	500	Unspecified improvement plus bore	A
Fish	26	Group of dry mounds plus several small active; like Umatcha Springs	Fair	100	Excavated	X
Goonerah	27	Isolated mud spring	Outstation; good		Unspeeified improvement	X
Gooning	28	1 large, wet patches/pools (to 12 ft diameter) & several minor in vicinity. Free of odour and taste despite a dense growth of reeds around the spring	Station (dry season); excellent	1500	Well, pump, tanks, reservoir	X
Gourminya	29	Unspecified, 'unimportant'				X
Gowcrah	30	Unspecified, 'unimportant'				?
Horseshoe/ Twomanee	31	'These springs (7 main) form practically one group round the granite outcrops. On the first visit to Twomanee which was in the middle of a summer's day (14/12/11) no well-defined springs could be found. On this visit however at 8am distinct flows were noticed in places that were merely wet patches on the previous occasion. It appears from these observations that the flow is not constant throughout the day though the falling off would be more noticeable in mid summer when the evaporation is a maxim' 'In most of the springs the evaporative effect is very marked, and especially at the main Horseshoe Spring. Here the water issuing from the bog surrounding the spring (during a week's inspection) appeared to advance and recede with comparative regularity according to the time of day; reaching approximately 1 chain further at 8am than at 5pm (when it began to advance). The effect was more marked on the very hot days so that observations taken at different periods might be expected to disagree'.		15000		A
Kapongee& Kapingee	32	Unspecified				X
Kaponyee	33	Unspecified, 3rd best spring in district		3rd big		X
Kungie	34	Boggy ground that never discharges any water, not mud-spring like				X
McNichols	35	A few scattered mounds, 'unimportant'				A
Nowanee	38	Unspecified, 'unimportant' (largest group in district)				X
Mingeburra	36	Two small groups of non over-flowing springs 'Since the bore was put down, he [J.G.Cooney, driller and selector] says that several of the springs have dried up, and it is now safe to ride across a flat which was originally very boggy'.	Good		Excavated, bore	X
Myrton	37	Mounds 2-7 ft high, a few discharge small quantity of water. Surplus from the bore forms a small swamp overgrown with reeds peculiar to the spring			Bore	X
Ooliman (at bore)	39	Grassy bog 20ft wide plus smaller dry springs 'This includes a flowing spring, which yields about 1500 gallons of good quality water per day. This spring is west of the bore and cool. The other members of the group are now dry but formerly yielded water before the interference referred to in Ooliman bore notes co-incident with the sinking of that bore'. 'A few dry springs belonging to this group lie about 3 chains north of the bore and in the crater of one of these Edwards found a sample of fairly rich copper ore, which had evidently been thrown up during an 'explosion' of the spring.'	Good	1500	Bore (28,000 gpd)	A

TABLE 1 (*Cont.*)

Ooliman (at hut)	40	Two main springs and a few non-flowing improved mounds 'It was this group that was reported to have failed on the completion of Ooliman bore. It is situated about 1 mile south west of the bore...'	Outstation; 1st Class	112	Wells plus troughing	X
Talaroo bore	41	Unspecified			Bore (75,000 gpd)	X
Tareen	42	A small flowing spring	Homestead; good		Well, troughing, pump, tank	X
Tarko	43	Largest group of mounds in district (extending 3 miles). 3 main fluwing springs, a few seattered wet patches of sand, some wet and overflowing mounds, main spring no longer used and overgrown with reeds	Travelling public; excellent	3000	Troughing, exeavation	X
The Springs	44	A small group of mud springs not overflowing			Tank	?
Thorlinda	45	Group of unspeeified springs			3 wells and bore	X
Tilberry	46	2 flowing springs and a few dry mounds	Outstation	1110	Well, troughing, pump, tank	A
Tunca	47	Group of springs of unspecified eharaeter		150	Well	X
Tunga	48	Unspecified '...since sinking Tunga bore the flow has stopped and the ground is almost dry'.		Fairly large	Bore (20,000 gpd)	X
Tungata	49	About 50 large dry mounds and 2 overflowing springs; growth of tall reeds	Good	1100	Well, exeavation, troughing	A
Umatcha	50	A group of dry mounds to 20ft high & 100ft diameter over several aeres				X
Wanko	51	Unspecified, 'unimportant'				A
Wiggera	52	Best in district, one large (flows for 3 miles) and several carpet springs. A few reeds flourish on the edge of the pool & good feed in the watercourse 'The supply is now very small hut a boundary rider who was on the run before the adjacent bore was sunk states that the spring gave out when the bore first struck water. Originally the spring maintained the same length of drain as the bore now does. [Water] Quality: exeellent'.	Good/exeellent	42100	Truughing, exeavation, bore	X
Wirrarah (Werrerah)	53	A group with one flowing spring and 12 wet mounds are 1mile southeast 'The fluw was originally, judging from the deseription of one of the station hands, about 10000 gpd, but now it does not exceed 200 gpd (diffieult to estimate exactly)',	Good	10000	Well, bore	X
1m S of Werrerah	54	12 mounds wet at the surface but non-flowing				X
Wooregym	55	A group of springs in an area about 220 by 110 yards. Other springs not improved give off large quantities of gas (as does Wiggera)	Homestead; good		6 wells, bore (48,000 gpd) in near vieinity	A
Youleen (Youlain)	56	2nd best in district, 2 main and several smaller springs, 5 acres of swamps, growth of green grass, water temperature 103°F, eold spring unlocated	Good	30000-40000		X
Bourke Supergroup						
Tego	57	A small group of mud springs 'Robertson (Tego) states that the discharge apparently does not fluetuate during the various seasons, but of eourse the effeet of evaporation in summer eauses the general appearanee to alter'.		200	Well, tank, dam	A
Towry	58	Boggy areas, bogs and pools plus ½ mile2 of small springs. Patches of water grass, bog of miranda (Typha spp.) 'The discharge does nut vary with the seasons and the springs are a fairly regular watering plaee'.	Usual	700	Exeavated, bores	A

surveyed in the Bourke Super-group in 1911 contained active springs in 1999.

Some of the currently inactive springs are mounded mud springs that previously flowed relatively small quantities of water. However, larger springs have also stopped flowing, including the largest three surveyed: Wiggera, Youlain and Kaponyee Springs (Table 1). Other springs had ceased to flow altogether by 1912 (e.g. Mingeburra, Ooliman, Tunga), and Ogilvie & Edwards documented that some springs, such as Werrerah Springs had greater flows prior to bores being sunk (Table 1). The original spring flow estimates and descriptions should therefore be treated as underestimates of the pre-artesian bore era.

Many bores were sunk adjacent to springs. For example, from Bingara and Dynevor Downs runs Ogilvie and Edwards recorded that 'All the bores on the runs, 6 running and 3 abandoned, were put down within a few yards of mud springs ...' Dunstan (1913) noted that some bores on runs that contained springs, including Dynevor Downs had reduced flows within a few years after they were sunk (Table 1). Several of the bores in the district initially flowed more than 10ML/day, and recent bore-flow measurements are 10% of the original estimates (Table 2). The large flows from bores and their proximity to springs almost certainly accounts for the observed reduction in spring-flows. None of the springs active in 1999-2000 appear to have increased in flow since 1911-12.

It is important to consider natural fluctuations in spring flows when assessing longer-term changes in flow rates (e.g. Williams & Holmes, 1978). Ogilvie & Edwards report that Towry Springs had a constant flow rate, the flow of Horseshoe/Twomanee fluctuated with daily evaporation and the flow from Tego Springs did not apparently fluctuate between seasons although a summer evaporation effect was evident (Table 1). However, in most cases such changes would have been inconsequential compared to estimated flow rates and spring activity. Irregular discharges from mud springs were recorded for Caiwarro and an occasional 'explosion' was reported for Ooliman Springs (Table 1). This is consistent with anecdotes from landholders regarding mud spring activity collated during the 1999-2000 survey. Some large springs have only become inactive in recent decades. The habitat notes on a Queensland Herbarium specimen of *Cyperus laevigatus* indicate that Kaponyee spring was active in 1971 and a local resident has confirmed that Wiggera spring was active in the 1960s (I. Pike, pers. comm.).

Two-thirds of all springs recorded by Ogilvie & Edwards had been modified in some way prior to 1912, mostly by constructing wells. Wells were often boxed (lined) to a level above the natural outlet of the vent thus eliminating any wetland associated with the spring.

At least 10 of the 14 Eulo Super-group springs whose descriptions included references to vegetation have become inactive. Of the remaining four, two wetlands are supplied by abandoned bores (Ooliman & Dewalla), one has been decimated by stock (Tungata) and Horseshoe has been excavated to form a small dam. None of the 14 contained GAB endemic plants during the recent survey. Descriptions such as bogs, swamps, peat and carpet springs were applied to seven springs (Table 1). Such descriptions are compatible with situations in which GAB endemic plants have been observed, both in the Eulo district and elsewhere in the GAB (Queensland Herbarium unpub. data) and may represent former habitat. Wiggera Springs was the largest spring in the district and described as comprising carpet springs. A local resident recalls the endangered *Eriocaulon carsonii* from that spring when it was active (I. Pike, pers. comm.).

This study provides further evidence of the impact of bores on springs. The positive news is that examples exist from within the study area of increased artesian pressure since the bore-capping program (GABCC, 1998). Thus completion of the bore rehabilitation program and judicious prioritising of GAB water use may enhance flows for remaining springs and could even reactivate springs.

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TABLE 2. Bores from the Eulo 1:250 000 map sheet for which pre-1913 and recent flow rates are available. Flow rates provided are the maximum when uncontrolled. Initial flow rates of named bores are sourced from Dunstan (1913). Bore information is courtesy the Department of Natural Resources and Mines with some initial flow rates sourced from Dunstan (1913). 'Controlled' applies to bores that have been capped.

Bore Name/ number	Pre-1913 flow (L/day)	Recent year of inspection	Bore status	Recent flow (L/day)	% pre-1913 flow
4560	285,120	1992	Controlled	144,288	50.6
Mulgar(9) 4553	998,011	1992	Un-controlled	340,416	34.1
1491	31,104	1956	Controlled	8,640	27.8
Kungie 4550	1,168,655	1972	Un-controlled	304,992	26.1
403	16,498,080	1987	Controlled	4,192,128	25.4
Tunka 1617	13,608	1997	Un-controlled	3,456	25.4
Taleroo 1619	340,200	1937	Controlled	76,896	22.5
1831	307,584	1992	Controlled	63,936	20.8
Woorcgym 1488	217,728	1974	Un-controlled	43,200	19.8
Woolshed(2) 1616	90,720	1997	Un-controlled	17,280	19.0
4547	2,445,984	1993	Un-controlled	315,360	12.9
2272	5,069,088	1987	Un-controlled	595,296	11.7
4551	12,274,848	1992	Controlled	1,294,272	10.5
1821	5,908,896	1992	Controlled	610,848	10.3
4552	1,249,344	1982	Un-controlled	67,392	5.4
2276	6,590,592	1985	Un-controlled	330,912	5.0
Colanya 1613	408,240	1979	Un-controlled	19,872	4.9
Bingara 1486	181,440	1997	Un-controlled	6,912	3.8
4561	5,227,200	1982	Un-controlled	145,152	2.8
402	11,643,264	1987	Un-controlled	203,904	1.8
Tunca 1487	90,720	1997	Ceased	0	0
Tarko 1490	45,360	1911	Ceased	0	0
Woolshed 1614	77,112	1969	Ceased	0	0
Caiwarro 1820	113,400	1950	Ceased	0	0
1822	12,960	1911	Ceased	0	0
2275	432,000	1928	Controlled	0	0
Ooliman 2427	127,008	1960	Ceased	0	0
2429	104,544	1937	Ceased	0	0
Mulgar(11) 4554	4,091,904	1943	Ceased	0	0
Boortra 4556	12,273,120	1959	Ceased	0	0
Tinnenburra(1) 4558	4,089,312	1915	Ceased	0	0
Mulgar(10) 4559	136,080	1974	Ceased	0	0
Total	92,543,226			8,785,152	9.5

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AN OBSERVATION OF CALLING NORTHERN TINKER FROGS (*TAUDACTYLUS RHEOPHILUS*) ON MOUNT BELLENDEN KER

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Freeman, A.B. 2003 06 30: An observation of calling northern tinker frogs on Mount Bellenden Ker. *Memoirs of the Queensland Museum* **49**(1): 295-297. Brisbane. ISSN 0079-8835.

Since its 'rediscovery' in 1996 the northern tinker frog has only been recorded spasmodically on Mount Bellenden Ker with calling males last recorded in 1996. In December 2000 calling northern tinker frogs were recorded on seven occasions during two trips. Subsequent trips by QPWS staff and James Cook University researchers have failed to detect the species at the site. It is concluded that this is a critically endangered species and some basic recommendations are detailed for future monitoring. ❐ *Northern tinker frog, calling, management, endangered, Mount Bellenden Ker.*

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Taudactylus rheophilus is an endangered species (Queensland Nature Conservation Act 1994, Environmental Protection and Biodiversity Conservation Act 1999) known from Carbine Tableland, Lamb Range, Thornton Peak and Mt Bellenden Ker in the Wet Tropics (McDonald, 1992). Between 1991 and 1996 this species was not recorded in the wild and it was assumed that it had declined or even disappeared. In 1996 they were 'rediscovered' on Mt Lewis and Mt Bellenden Ker (Marshall, 1998). Since this time reports of this species at both these sites have been few and spasmodic (Hero et.al., 2002; D. James, pers. com.; E. Bolitho, pers. com.; Keith McDonald & A.B. Freeman, unpubl. data). No other populations have been located despite a significant search effort, particularly on the Carbine Tableland (K. McDonald & A.B. Freeman, unpubl. data).

The records of *T. rheophilus* on Bellenden Ker, between 1996 and November 2000 include five individuals recorded along 150m of stream in 1996 (Marshall, 1998), one juvenile captured in 1998 (Hero et. al., 2000) and an unconfirmed observation of a *Taudactylus* tadpole in 2000 (E. Bolitho, pers. com.). The latter was made by a researcher with 4 years experience with *Taudactylus* tadpoles from mid-east Queensland and was based on the type of pool that it was observed in and the behaviour of the tadpole. Unfortunately the animal was not captured so a confirmed identification could not be made.

This paper details observations of *T. rheophilus* made by QPWS staff on the 12th, 13th, 18th, 19th and 20th of December 2000 on Mt Bellenden Ker and three subsequent trips on the 3rd September, 2001 and 23rd and 24th of January, 2002 and the 26th April 2002.

STUDY AREA

Mt Bellenden Ker is the second highest peak in Queensland at 1582m and part of the Bellenden Ker Range. The summit vegetation is low growing simple microphyll vine-fern forest (Tracey, 1982). On Mt Bellenden Ker *T. rheophilus* is known from a perennial stream in the upper catchment of the Mulgrave River, 600m SE of the summit (17°15'56", 145°51'22").

METHODS

The first *T. rheophilus* sighting made by the QPWS team occurred on the 12th December 2000 during an opportunistic survey associated with an ongoing frog monitoring program. Subsequent searches concentrated on the area where the initial observation had been made. Active searching (turning rocks) was abandoned when it become apparent that this was likely to cause damage to the habitat. Subsequent sampling involved passively recording calling individuals.

When a *T. rheophilus* was seen or heard for the first time air temperature and humidity along with general weather information were recorded for the site (the one exception for this was the morning of the 13th).

For the two individuals that were captured snout vent length (SVL) was measured to the nearest 1mm using 200mm dial calipers and weight was taken to the nearest 0.1gm using a

TABLE 1. Sightings of *T. rheophilus* on Bellenden Ker. * Tissue samples were taken for analysis by disease researchers at James Cook University, Townsville from two individuals. These samples subsequently came back as negative for chytrid fungus.

Date	Time	Weather	No. of frogs	Site	Measurements
12 Dec	20:00	Overcast, Light showers, Air temp 14.5BC, Humdity 94%	1*	Calling between rocks in crevice 52cm above stream. Captured by hand.	SVL: 24.9mm Wght: 1.65g Sex: ♂
13 Dec	08:10	Overcast, Light showers, Air temp cool.	1	Calling amongst rocks and streamside vegetation. Ceased calling 08:20.	
18 Dec	15:00	Overcast, Light rain, Air temp 18.5BC, Humidity 95%	2*	Found under rock on edge of water. One captured by hand.	SVL: 20.5mm Wght: 0.85gm Sex: ?
18 Dec	15:30	Overcast, Heavy rain, Air temp 18.0Bc, Humidity 100%	2	Calling amongst rocks and streamside vegetation.	
19 Dec	08:00	Overcast, Light rain, Air temp 16.0BC, Humidity 100%	2	Calling amongst rocks and streamside vegetation. Still calling at 09:00.	
19 Dec	15:45	Overcast, Heavy rain, Air temp 16.0BC, Humidity 100%	2	Calling amongst rocks and streamside vegetation. Calling intermittent before petering out around 16:05.	
20 Dec	08:10	Overcast, Light showers, Air temp16BC, Humidity 95%	1	Calling amongst rocks and streamside vegetation. Calling continued at irregular intervals until 09:10.	

10gm Pesola™ spring balance. Sex of the male was ascertained by the presenee of nuptial pads.

RESULTS

The initial observations, on the 12th of Deeember 2000, were made by A.B. Freeman, L. Dwyer, C. Schmidt. During this trip two calling *T. rheophilus* were heard over two days. One of these was eaptured to confirm identification. This was the first time ealling *T. rheophilus* had been recorded on Bellenden Ker sinee 1996. A further trip was made for two days during the following week in an attempt to elarify the status of *T. rheophilus* on Mt Bellenden Ker. This was after a trip to the Carbine Tableland to establish if *T. rheophilus* was active at this site.

Approximately 18 hours was spent at the Bellenden Ker site over the two trips, with searehing taking plaee during the day and the night. Most of this time was spent at the site where frogs had previously been recorded.

T.rheophilus was observed or heard seven times during the two trips to Bellenden Ker (12-13th December and 18-20th Deeember) (Table 1). Observations ineluded calling individuals, visual sightings and individuals in hand. Two individuals were captured by hand, one individual was observed but not eaptured and another 2-3 individuals were heard.

Over 400m of stream was searched above, and below, the site while the frogs were ealling. Most of the search effort coneentrated on downstream habitat, as it appeared to be more suitable for *T. rheophilus* although historically the whole stream had *T. rheophilus* (K. McDonald, pers. eom.). All the observations of *T. rheophilus* were made in an area of habitat less than $9m^2$ in size.

On the 21st Deeember, 2001 a trip was also made to the Carbine Tableland in the hope that the activity on top of Bellenden Ker would be replicated at the other site where they were known to be present. No aetivity was deteeted on this trip.

Subsequent trips were made in September 2001, January 2002 and April 2002 to the Bellenden Ker site. The September and April trips were made to ascertain if breeding had taken place by checking the site for tadpoles. None were deteeted. The visit in January took plaee over two days with the primary aim of surveying the stream day and night, no aetivity was deteeted.

DISCUSSION

The number of individual frogs within this area appears to be small. A eonservative estimate of the population was made at 3-5 males. While it cannot be said for certain that frogs do not occur outside this area, searches both upstream and downstream of the site have not located other *T. rheophilus*. This ineludes four previous searehes by QPWS staff of the stream during earlier trips to the site over a period of two years. These searehes were earried out at similar times of the year in similar eonditions. Experienced frog researchers from James Cook University also

made ten trips to the summit of Bellenden Ker between the 12th January and the 2nd March 2003. On each of these trips the stream where *T. rheophilus* was recorded was checked for frog activity with none being recorded (E. Bolitho, pers. com.; Richard Retallick, pers. com.).

There is little doubt that *T. rheophilus* is a critically endangered species surviving in very low numbers on Mt. Bellenden Ker and possibly the Carbine Tableland. The Carbine Tableland population has not been detected since January 1999 (K. McDonald & A.B. Freeman, unpubl. data). I am concerned by the lack of *T. rheophilus* activity recorded on Bellenden Ker since December 2000. Three trips between January 2001 and April 2002 have failed to find any sign of the species.

T. rheophilus is not an easy species to work with on Bellenden Ker. The specific habitat of the frogs is notable for the dense ground layer of *Helmholtzia acorifolia* on granite boulders. Calling individuals are difficult to locate visually in the densely vegetated rocky terrain. It was noticeable that the actions of just one person searching for calling frogs amongst this habitat resulted in significant trampling of the vegetation on part of the site. Future monitoring should concentrate on censusing calling frogs during the day and night or nighttime searches for non-calling individuals out on vegetation or rocks. Active searching by turning and dismantling habitat should be kept to a minimum. Visits to the specific site of *T. rheophilus* other than conducting monitoring should not be permitted.

MANAGEMENT RECOMMENDATIONS

The population should be monitored more frequently than is currently the case particularly over the early wet season months (Oct-Dec).

Visits to the specific site by people other than those directly involved in the monitoring program should not be permitted.

Future monitoring should concentrate on the census of calling animals and night time searches for non-calling individuals out on vegetation and rocks. Active searching involving disturbing habitat should be kept to a minimum.

ACKNOWLEDGEMENTS

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FAUNAL SURVEY OF NEW ENGLAND. V. THE LIZARDS AND SNAKES

HAROLD HEATWOLE, JOHN de BAVAY AND PAUL WEBBER

Heatwole, H., de Bavay, J. & Webber, P. 2003 06 30: Faunal survey of New England. V. The lizards and snakes. *Memoirs of the Queensland Museum* 49(1): 299-325. Brisbane. ISSN 0079-8835.

A 34-year study (1966-2000) of the lizards and snakes of the New England region of New South Wales yielded 14 species of geckos, 4 of pygopodids, 8 of dragons, 3 of goannas, 47 of skinks, and 30 of snakes, for a total of 106 species. Four additional species reported by Swan (1990), and an additional one from the Atlas of NSW Wildlife brings the total known squamatan fauna of New England to 111 species. Most terrestrial families of squamates in New England represent 10-15% of the total Australian species. The exceptions are the families Elapidae (26%) and Colubridae (18%). Generic representation is higher and more variable. A fifth of the species are widespread. Other species are predominantly separated into eastern and western faunal groups. In some species the Great Dividing Range coincides with east-west distributional boundaries. In others, the borders of the distributional range lie one side or the other of this topographical feature. In both western and eastern groups, there are species associated mainly with either the northern or southern quadrants; otherwise distributions of only a few species are oriented with respect to the north-south axis. There were no strictly central species. Some species are represented by only one or a few records and the full extent of their distributions may not be appreciated, or they may be sparsely distributed, rare, or cryptic. A number of species were distributed randomly with regard to particular environmental attributes; these were unlikely to be affecting distribution within New England. Where correlations did exist, causal effects could only be hypothesised, but optimal habitats could be defined by over-representation in localities with particular levels of elevation, rainfall, or temperature, or characterised by certain types of vegetation, rock or soil. ❐ *New England, snakes, lizards, faunal survey, distribution, habitat.*

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An initial paper of the faunal survey of New England described the general geography of the area (Heatwole & Simpson, 1986); this was followed by accounts of the gastropods (Simpson & Stanisic, 1986), birds (Ford & McFarland, 1991) and frogs (Heatwole et al., 1995). The present paper reports on the lizards and snakes.

There have been several interpretations of the boundaries of New England (see Lea et al., 1977 and electoral maps). We recognise the boundaries as defined in the previous papers of this series (Fig. 1).

Treatment of the fauna is at the specific level; subspecific designations are not included.

METHODS

In the interests of conservation, we collected only a few voucher specimens of each species from any given area. Nevertheless, over the 34 years of the study (1966-2000) we collected and identified more than 6,000 specimens of snakes and lizards and deposited them in the Australian Museum.

This material was augmented by other herpetological collections in the Australian Museum (up to 2000), and by the holdings of the Museum of Victoria, and the Queensland Museum (both up to 1996). Initially, we eliminated records referring to specimens that had been discarded or lost, or which had deteriorated beyond accurate identification, corrected some misidentifications, and verified or corrected data for unusual specimens such as geographical outliers. After this editing, we relied heavily on the registers of those museums. Especially important has been the progressive upgrading by the Australian Museum of their herpetological collections, whereby incompletely unidentified specimens were identified, previously identified specimens checked for accuracy, nomenclatural changes incorporated, and geographical co-ordinates and other data verified or corrected.

Taxonomic nomenclature follows that of Cogger (2000) and Cogger et al. (1983), but incorporates recent name changes and generic allocations by King (1983), Wells & Wellington

(1985), Ingram & Covacevich (1988), Hutchison (1990), Hutchison et al. (1990) Sadleir (1990), Rawlinson (1991), Greer (1992, 1997), Hutchison & Donnellan (1992), Couper et al. (1993, 1994, 1997), Sadleir et al. (1993) and Shea (1995a, 1995b).

A number of surveys and environmental consultancies for specific purposes amassed a corpus of data relating to the New England area. Specimens arising from these studies were deposited in the Australian Museum and automatically became part of our database. In addition, a large number of the records were not based on voucher specimens, but rather upon field identifications of varying reliability. We have not included any sight records in our database but do discuss them below where relevant.

Our final, edited dataset, consisting of our collections plus the other acquisitions of the three museums, is based on more than 12,800 specimens that were collected from the late 19th century to the end of the twentieth century. Using the statistical package, StatView, locality data were formatted for the ArcView Mapping System to produce distribution maps of each species. In this system, multiple records of a given species for a particular locality were grouped as a single entity and latitudes and longitudes from museum records were converted to a decimal degree.

The final edited dataset totalled 4,045 records and comprised 3,175 localities within the boundaries of New England (Fig. 1), and 888 records from sites immediately extralimital (Figs 2, 3-108) that were included for mapping purposes. This has been placed in each of the three museums both as hard copies and CD ROM.

The New England survey of frogs (Heatwole et al., 1995) related species distributions to four environmental parameters: mean daily minimum temperature for July, mean annual rainfall, elevation, and vegetation. Because many squamates behaviourally thermoregulate, are cryptic, or are substrate-dependent in various ways, an enlarged set of parameters was employed, including soil type and rock type. Heatwole & Simpson (1986) presented a map of the lithology of New England based on 'An Atlas of New England' (Lea et al., 1977). For the present paper an improved map, derived from the New South Wales Department of Mineral Resources 1/25000 Geological map, was used.

The soil map derives from Lea et al., 1977. This was digitised, and the map prepared using the Environmental Research mapping Program

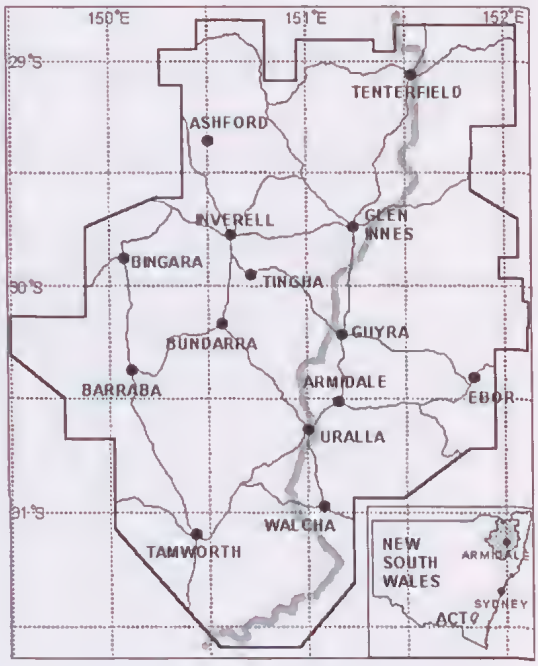

FIG. 1. Collecting grid and study area within New South Wales indicating the main towns, connecting roads, and the Great Dividing Range (GDR). Inset shows the location of the study area in New South Wales.

(ERMS) in the Armidale office of the National Parks and Wildlife Service of New South Wales (Ferrier,1989).

The vegetation map is based on a modification of the classification of vegetation systems for northeastern New South Wales (NSW National Parks and Wildlife Service, 1994). The nine categories of that classification were lumped into three categories: 'disturbed' (including pastoral and agricultural land), 'dry forest and woodland' and 'wet forest' (including rainforest).

New, more detailed maps of elevation, rainfall and temperature were prepared. The Environmental Research Mapping System (ERMS) in the Armidale office of the National Parks and Wildlife Service of New South Wales (Ferrier, 1989) was used to prepare maps of the distribution of soils, and the distribution of various variables.

Long-term monthly means of minimum temperature, maximum temperature, and precipitation were derived by linking a gridded digital elevation model with climate surface models developed by Hutchinson (1989). These

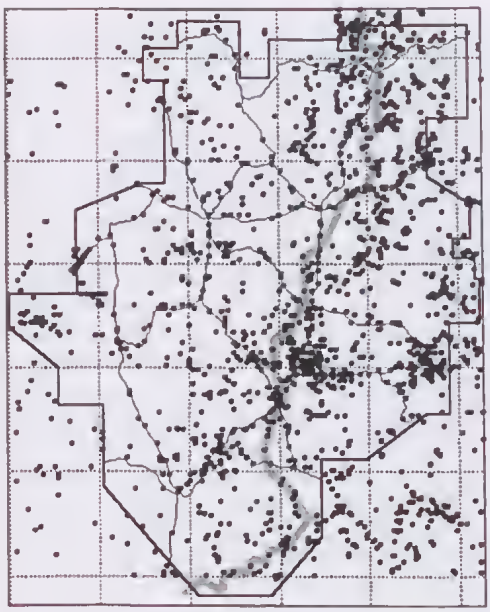

FIG. 2. Location of all collecting sites for squamates in the present study, both within the study area and immediately extralimitally.

monthly estimates were then used to derive, for each grid cell in the study area, the mean minimum temperature of the coldest month, the mean maximum temperature of the hottest month, and the mean annual rainfall. Values for the squares of the grid were grouped into a series of categories. The five categories for mean minimum temperature (°C) of the coldest month were: -4° to -2°; -1°; 0°; 1°; 2°-6°. Those for the mean maximum temperature (°C) of the hottest month were: 21°-23°; 24°; 25°; 26°-28°; 29°-32°. Six categories for mean annual rainfall (mm) were: 700; 700-800; 801-900; 901-1000; 1001-1100; >1100. Mean elevations (m) of squares were grouped as follows: 0-700; 701-900; 901-1000; 1001-1100; 1101-1600. Finally squares of the grid were tallied as to the type of vegetation, soil and parent rock they contained and the data grouped accordingly. Vegetation: disturbed; woodland and dry forest; wet forest. Soils: RP (red podzolic); YS/YP (yellow sol/yellow pod); YP/GP (yellow pod/gley pod); CP (chocolate prairie); YP (yellow podzolic); BE (black earth prairie); all others (the remaining, less common soil types combined). Type of parent rock: sedimentary rocks; granite; basic igneous rocks; acid volcanics; all others (the remaining, less common types of rocks).

For statistical treatment, the proportion of grids falling into these various categories was calculated separately for each environmental attribute. Then from these proportions, the expected number of grids in each category expected to be occupied by a given species was calculated and the observed values compared to expected values and tested for statistical significance by chi-squared tests, using a rejection level of 5%. These tests were conducted in 1996 on the database available at that time and not recalculated to include the few later acquisitions; only localities located within the boundaries of New England (Fig. 1) were included in the statistical analyses.

For valid statistical testing, no category should have an expected value less than five. Some categories of vegetation, soil type and rock type were sparsely represented in the region and did not meet this requirement. To overcome this, the smaller categories were lumped to raise their collective expected value into the appropriate range. Some environmental parameters had more disparate frequencies of categories than did others. For example, in vegetation systems, rainforest and other wet forest occupy only a small proportion of the total area of New England, and there were relatively few collecting localities located within it. Nevertheless, it was unrealistic to lump these important habitats with those of a distinctly different character merely in order to allow the mechanics of statistical testing to proceed. For this reason, in order to reach the criterion of an expected value of five for rainforest/wet forest, only species of squamates with a high number of occurrences (N) in New England could be tested. Other parameters, with more uniform frequencies of environmental categories, could be tested for species with a lower N. The minimum values of N for the different environmental parameters after lumping of categories were: Elevation = 28; Rock Type = 34 for four categories (an N of 95 allowed testing of five categories); Maximum Temperature = 36; Rainfall = 46; Soils = 48 for five categories and 80 for six; Minimum Temperature = 49; Vegetation System = 74.

Two examples (Table 1) illustrate the technique. (1) *Eulamprus quoyii* in relation to elevation: this species occurred in 64 grid squares in the study area. Since 26.39% of the grid squares had a mean elevation of 0-700m, if this species were distributed at random with respect to elevation, then it would be expected to occur in 16.89 grid squares at this elevation (26.39% of 64); the

observed value was 11. Similarly expected values were 11.96 for 701-900, 10.42 for 901-1000, 12.2 for 1001-1100, and 12.44 for 1101-1600. The corresponding observed values were: 8, 16, 13 and 16. The chi-square value of the comparison of observed to expected values was 7.414 (0.25>P>0.10). Since P>0.05, *E. quoyii* was considered to be distributed randomly with respect to elevation, within the range of elevations occurring within the study area. (2) *Ctenotus robustus* in relation to rainfall. The expected (observed) values for the 46 grid squares in which this species occurred was: 4.50 for <700mm rainfall, 14.86 for 700-800mm, 9.17 for 801-900mm, 5.82 for 901-1000mm, 5.43 for 1001-1100, and 6.17 for >1100mm. The respective observed values were 8, 23, 8, 5, 2 and 0. The chi-square value was 15.197 and 0.01>P>0.005 (highly significant). Thus, this species was not randomly distributed with respect to rainfall. Note that the observed values were greater than expected by randomness in the first two categories (<700mm and 700-800mm) and less than expected in all the rest. The optimal habitat for *C. robustus* therefore seems to be the drier parts of the area.

For some species, over-representation occurred only in one category, in other species over-representation occurred over a broader range of values and encompassed several categories.

Copies of the detailed statistical tests, including all observed and expected values, chi-squares and P values, as well as histograms of frequency distributions of environmental parameters, have been placed on file in the Australian Museum and in the Queensland Museum.

Although nearby extralimital localities were plotted on species' distribution maps, only the localities within the boundaries of the New England region were included in the statistical analyses.

A transparency of the State of New South Wales, with the area of New England delineated as defined in the present study, was produced at the same scale as Swan's (1990) maps. By overlapping this transparency onto Swan's maps and comparing them, the species and localities included in his study were detected and compared with ours.

COVERAGE

The long duration of this survey allowed opportunity for a comprehensive geographical coverage of the area (Fig. 2). Collections were made throughout the area with no large gaps, although the collecting localities were slightly less densely distributed in the west than elsewhere.

Even with a relatively complete geographic coverage, a distorted picture could be obtained if important habitats were poorly represented. For example, not collecting along streamsides in New England would have failed to reveal the presence of several species. We attempted to cover all habitats. In order to assess the extent to which that attempt was successful, the areas covered by each category of the various environmental parameters was calculated from the computer-generated environmental maps, and the number of collecting sites represented in each category ascertained. For each parameter, the number of collecting sites in a given category was roughly proportional to the representation of that category in the region. Thus, it appears that all recognised habitats were adequately covered.

The seasonal coverage was not as good. Many localities were visited only once. Consequently, if certain species were active only outside that period, they would have been missed.

OTHER RECORDS FOR NEW ENGLAND

Swan's (1990) maps were based partly on records not available to us and they add four species (*Hypsilurus spinipes*, *Tympanocryptis diemenensis*, *Lerista punctatovittata*, *Cryptoblepharus carnabyi*) to the fauna of New England. He reported *Phyllurus cornutus* from the area, but Couper et al. (1993) restricted this species to northeastern Queensland and allocated the New England population to *Saltuarius swaini*. Swan also reported *Ramphotyphlops broomi* from New England but Shea (1995) demonstrated the New England species to be *R. wiedii*. Thus, we have excluded *Phyllurus cornutus* and *Ramphotyphlops broomi* from the list of species from New England.

The Sarah River Survey (Webber & Heatwole, 1991), an action plan for threatened Australian reptiles (Cogger et al., 1993) and the Eastlink Survey of 1995-1997, conducted along a transect through northern New England and southern Queensland (Debus, unpubl. data) yielded no species for the New England squamatan fauna beyond those listed in Table 1 from other sources. The Atlas of NSW Wildlife of (NSW National Parks and Wildlife Service, database of the year 2000) summarised all records from New South Wales, including New England, arising from a

variety of sources and of varying reliability. Almost all the records in the Atlas that were based on voucher specimens had already been included automatically in our database by virtue of the specimens having been deposited in the Australian Museum.

However, two new species records, *Ctenotus eurydice* and *Denisonia devisi*, were based on voucher specimens. The former is now regarded as an invalid species (Sadleir, pers. comm.), but the latter can be added to the known fauna of New England.

The following species were recorded from New England only on the basis of field identifications: *Phyllurus platurus*, *Egernia striata*, *Eulamprus tympanum*, *Hemisphaeriodon gerarrdii*, all with a reliability index of 4 or 5 (with 1 being most reliable, 6 least reliable). The last is known extralimitally just east of New England and further investigation may well extend its range into the region. However, the first three species almost certainly represent erroneous identifications and we do not consider them part of the New England fauna; their known ranges are far removed from New England (Cogger, 2000).

One of the species listed in our database, *Denisonia maculata*, may be in error. The record is based on a single specimen from the Australian Museum (AM R4765) that was later donated to the Museum of Comparative Zoology at Harvard. J. Rosado (pers. comm.) indicated that because of renovations this specimen would be unavailable for an identity check for at least another year. Cogger (2000) showed the range of *D. maculata* as coastal central Queensland, well beyond the limits of New England. *D. maculata* is closely related to *D. devisi* and the latter was once considered a subspecies of the former (Cogger et al.,1983). *D. devisi* is one of the species reliably recorded from New England by the Atlas of NSW Wildlife (Table 1 and see above) and it is likely that the purported specimen of *D. maculata* is, in fact, *D. devisi*.

Ctenotus eurydice: This species is now regarded as an invalid species(R. Sadleir, pers. comm.), since it cannot be reliably distinguished from *C. taeniolatus*, and is therefore excluded from our data base. The New England specimens of *C. eurydice* were SPXEIO13 (NSW Wildlife Survey, 1988), SPXE1OO6 (Atlas of NSW Wildlife) Neither of them can now be located.

Gehyra australis: There are three records of this species from closely adjacent sites in the Moonbi Ranges near Tamworth, NSW, (AM R29700, AM R75990, VM D55544). They form a cluster within a predominantly *G. dubia* population. The Australian Museum specimens could not be located, but that from the Victorian Museum was initially identified as *G. australis* by the Acting Curator of Herpetology, (D.J. Bray), and by one of the authors (J.de B). The specimen was then referred to the Australian Museum where it was identified as *G. dubia* because of the presence of an internasal scale, a characteristic of that species (R.Sadlier, pers. com.). Consequently the three records of *G. australis* were transferred to *G. dubia*.

The reliably known squamatan fauna of New England therefore consists of (a) our database of 106 species (14 species of geckos, 4 of pygopodids, 8 of dragons, 3 of goannas, 47 of skinks, and 30 of snakes); (b) four additional species (2 dragons and 2 skinks) reported by Swan (1990); and (c) an additional species based on voucher specimens from the Atlas of NSW Wildlife database, for a total of 111 species.

Several more are immediately extralimital and further collecting may record their presence in New England. Faunal surveys involving parts of New England are in progress (e.g., Nandewar Ranges in western New England; Demon Nature Reserve on the Timbarra Plateau in eastern New England). The preliminary lists are subject to revision and reassessment before they are permissible for quotation; accordingly, it was not possible to include information from them in the present study.

THE REGIONAL FAUNA IN RELATION TO THE HERPETOFAUNA OF AUSTRALIA

The majority of Australian squamates live in tropical or arid habitats and are thus excluded from New England (Cogger, 2000). Overall, 14% of Australian species of squamates and 47% of the genera occur in New England. At the specific level, all Australian families of lizards are similar in their proportional representation in New England (12-15% of the total species from Australia) (Table 2). By contrast, the different ophidian families, have markedly divergent proportional representations in New England at the species level. The Typhlopidae and Boidae have about the same proportional representation (10-13%) as the saurian families, whereas the colubrids and the elapids are unusually well represented (Table 2).

Generic representation is higher than specific representation. All Australian monitors belong to *Varanus* and consequently New England has a

TABLE 1. List of the lizards and snakes known from the New England Region and a summary of their types of distributions. * recorded for the New England region by Swan (1990) but not present in our database; ** recorded in Atlas of NSW Wildlife database, based on a voucher specimen, but not in our database.
Key to symbols indicating distributional pattern within the New England region: U(e)=widspread and evenly distributed; U(p)=widespread but patchily distributed; U(s)=widespread but sparsely distributed; W= mainly distributed in the western part of the area; W(sw)=mainly in the southwestern sector; W(nw)=mainly in the northwestern sector; E= distributed mainly in the eastern part of the area; E(ne)=mainly in the northeastern sector; E(se)=mainly in the southeastern sector; S = mainly distributed in the southern part of the area; R= recorded from less than ten localities in our database.

LIZARDS

FAMILY AGAMIDAE (Dragons)
Amphibolurus burnsi (Wells & Wellington, 1985): W(nw)
Amphibolurus muricatus (White, ex Shaw, 1790): U(e)
Amphibolurus nobbi Witten, 1972: U(e)
**Hypsilurus spinipes* (Duméril & Duméril, 1851): E, R
Physignathus lesueurii (Gray, 1831): U(p)
Pogona barbata (Cuvier, 1829): W
Pogona vitticeps (Ahl, 1926): W, R
* *Tympanocryptis diemenensis*(Gray, 1841): S, R
Tympanacryptis lineata Peters, 1863: W, R
Tympanocryptis tetraporophora Lucas & Frost, 1895: W, R

FAMILY VARANIDAE (Monitors or Goannas)
Varanus gouldii (Gray, 1838): U(s)
Varanus tristis (Schlegel, 1839): W(nw), R
Varanus varius (White, ex Shaw, 1790): W, R

FAMILY GEKKONIDAE (Geckos)
Diplodactylus intermedius Ogilby, 1892: W, R
Diplodactylus vittatus Gray, 1832: W
Diplodactylus williamsi Kluge, 1963: W, R
Gehyra dubia (Macleay, 1877): W
Gehyra variegata (Duméril & Bibron, 1836): W, R
Heteronotia binoei (Gray, 1845): W
Oedura lesueurii (Duméril & Bibron, 1836): W
Oedura monilis De Vis, 1888: W, R
Oedura robusta Boulenger 1885: W
Oedura tryoni De Vis, 1884: W
Saltuarius swaini (Wells & Wellington, 1985): E
Saltuarius wyberba Cooper, Schneider & Covacevich, 1997: E(ne), R
Underwoodisaurus milii (Bory de Saint-Vincent, 1825): W
Underwoodisaurus sphyrurus (Olgilby, 1892); W

FAMILY PYGOPODIDAE (Snake-lizards)
Delma plebeia De Vis, 1888: W, R
Delma tincta De Vis 1888; W
Lialis burtonis Gray, 1835: U(p)
Pygopus lepidopodus (Lacépède, 1804): U(s), R

FAMILY SCINCIDAE (Skinks)
Anomalopus leuckartii (Weinland, 1862): W
Anomalopus mackayi Greer & Cogger, 1985: W(nw), R
Anomalopus verreauxii (Duméril & Duméril, 1851): E, R
Bassiana platynota (Peters, 1881): E
Calyptotis ruficauda Greer, 1983: E
Calyptotis scutirostrum (Peters, 1873): E(ne)
Carlia tetradactyla (O'Shaughnessy, 1879): W
Carlia vivax (De Vis, 1884): U(p), R
Cautula zia (Ingram & Ehmann, 1981): E, R
Caeranoscincus reticulatus (Günther, 1873): E(ne), R
**Cryptoblepharus carnabyi* Storr 1976: R
Cryptoblepharus virgatus (Garman, 1901): U(p)
***Ctenotus eurydice* Czechura and Wombey, 1982: E(ne)
Ctenotus robustus Storr, 1970: U(e)
Ctenotus taeniolatus (White, ex Shaw, 1790): U(e)
Cyclodomorphus michaeli Wells & Wellington, 1984: R
Egernia cunninghami (Gray, 1832): U(e)
Egernia frerei Günther 1897: E(ne), R
Egernia major (Gray, 1845): U(s), R
Egernia mcpheei Wells & Wellington, 1984: E
Egernia modesta Storr, 1968; W
Egernia saxatilis Cogger, 1960: W, R
Egernia striolata (Peters, 1870): W
Egernia whitii (Lacépède, 1804): E
Eremiascincus richardsonii (Gray, 1845): U(s), R
Eulamprus heatwolei Wells & Wellington, 1984: E(se)
Eulamprus kosciuskoi (Kinghorn, 1932): E(se)
Eulamprus martini (Wells & Wellington, 1985): E(ne)
Eulamprus murrayi (Boulenger, 1887): E
Eulamprus quoyii (Duméril & Bibron, 1839): U(e)
Eulamprus tenuis (Gray, 1831): U(s), R
Hemiergis decresieusis (Cuvier, 1829): U(p)
Lampropholis amicula Ingram & Rawlinson, 1981: E
Lampropholis caligula Ingram & Rawlinson, 1981: E(se), R
Lampropholis delicata (De Vis, 1888): E
Lampropholis elongata Greer, 1997; E(se), R
Lampropholis guichenoti (Duméril & Bibron, 1839): E
Lerista bougainvillii (Gray, 1839): W
Lerista muelleri (Fischer, 1881): W(nw)
**Lerista punctatovittata* (Günther, 1867):W(sw), R
Lygisaurus foliorum De Vis, 1884: W
Menetia greyii Gray, 1845: E(se), R
Morethia boulengeri (Ogilby, 1890): W
Nanoscincus maccoyi (Lucas & Frost, 1894): R
Ophioscincus truncatus (Peters, 1876): E, R
Pseudemoia pagenstecheri (Lindholm, 1901): S
Saiphos equalis (Gray, 1825): E
Saproscincus mustelinus (O'Shaughnessy, 1874): E
Saproscincus rosei Wells & Wellington, 1985: E
Tiliqua scincoides (White, ex Shaw, 1790): W

generic representation of 100%. There also is a high representation of Australian typhlopid (50%), scincid (63%) and elapid (85%) genera in New England but lesser generic representation by gekkonids, pygopodids, agamids, boids and colubrids (22-39%) (Table 2). Being inland, New England lacks the predominantly marine families of snakes.

TABLE 1 (*Cont.*).

SNAKES
FAMILY TYPHLOPIDAE (Blind Snakes or Worm Snakes)
Ramphotyphlops bituberculatus (Peters, 1863): W(sw), R
Ramphotyphlops nigrescens (Gray, 1845): U(e)
Ramphotyphlaps proximus (Waite, 1893): W(sw), R
Ramphatyphlops wiedii (Peters, 1867): W

FAMILY BOIDAE (Pythons)
Antaresia maculosa (Peters, 1873): W, R
Morelia spilata (Lacépède, 1804): U(p)

FAMILY COLUBRIDAE
Boiga irregularis (Merrem, 1802): E, R
Dendrelaphis punctulata (Gray,1827): E(ne), R

FAMILY ELAPIDAE
Acanthaphis antarcticus (Shaw & Nodder, 1802): E, R
Austrelaps ramsayi (Krefft, 1864): E(se)
Cacophis harriettae Krefft, 1869: E, R
Cacophis krefftii Günther, 1863): E, R
Cacophis squamulosus (Duméril, Bibron & Duméril 1854): E
Demansia psammophis (Schlegel, 1837): W
***Denisonia devisi* Waite & Longman, 1920: W
Drysdalia caronoides (Günther, 1858): U(p)
Furina diadema (Schlegel, 1837): W
Hemiaspis signata (Jan, 1859): E
Haplocephalus bitarquatus (Jan, 1859): U(s)
Hoplocephalus stephensii Krefft, 1869: E(ne), R
Notechis scutatus (Peters, 1861): E
Pseudechis guttatus De Vis, 1905: W
Pseudechis parphyriacus (Shaw, 1794): E
Pseudonaja textilis (Duméril, Bibron & Duméril, 1854): W
Rhinoplocephalus nigrescens (Günther, 1862): E
Simoselaps australis (Krefft, 1864): W
Suta dwyeri (Worrell, 1956): U(e)
Suta suta (Peters, 1863): W, R
Tropidechis carinatus (Krefft, 1863): E, R
Vermicella annulata (Gray, 1841): U(s)

DISTRIBUTIONAL PATTERNS

The distributions of all species (Figs 3-108) can be grouped into several general categories. The following interpretations have relied on our database and maps, supplemented by the additional localities on the maps of Swan (1990) and from specimen-based entries in the database of the Atlas of NSW Wildlife (NSW National Parks and Wildlife Service, 2000).

TABLE 2. Representation in New England of the total Australian Squamata. Total genera and species calculated from Cogger (2000); number of genera and species from New England from the present database plus valid additions from Swan (1990).

Species & genera in New England (New England taxa as % of Australian total)				
Taxon	Genera	Species	Genera	Species
Lizards				
Gekkonidae	18	111	6 (33)	14 (13)
Pygopodidae	8	34	3 (38)	4 (12)
Agamidae	13	65	5 (39)	10 (15)
Varanidae	1	26	1 (100)	3 (12)
Scincidae	38	379	24 (63)	50 (13)
Snakes				
Typhlopidae	2	40	1 (50)	4 (10)
Boidae	6	15	2 (33)	2 (13)
Acrochordidae	1	2	0 (0)	0 (0)
Colubridae	9	11	2 (22)	2 (18)
Elapidae	20	87	17 (85)	22 (26)
Hydrophiidae	12	31	0 (0)	0 (0)
Laticaudidae	1	2	0 (0)	0 (0)
Total	129	803	61 (47)	111 (14)

WIDESPREAD DISTRIBUTIONS. Widespread species usually have broad tolerances and habitat preferences. However, this is not always the case; sometimes widespread distributions may be patchy, reflecting discontinuous habitat within a large area. For example, although *Egernia cunninghami* is widespread (Fig. 46), it is largely restricted to exfoliating granite outcrops. The occurrences of *Physignathus lesueurii* and *Pseudechis porphyriacus* are locally restricted by the distribution of the rivers and other bodies of water with which they are closely associated. In other cases, especially in fossorial or secretive species, patchiness may be more apparent than real; a species like *Pygopus lepidopodus* may be recorded only sparsely from an area merely because it is difficult to find.

Twenty-two species (20% of the total squamatan fauna) were widespread in New England. Of these about equal numbers were evenly widespread in the area (8 species), and widespread but patchily (7 species) or sparsely (7 species) distributed over the region (Table 1).

EASTERN VERSUS WESTERN DISTRIBUTIONS. There are gradients in climate and natural vegetation in New England from east to west; accordingly, 74% of the species have either a predominantly western distribution, or a predominantly eastern one. The Great Dividing Range coincides with the boundary of the geographic range of only a few species (e.g., *Gehyra dubia*, *Eulamprus kosciuskoi*) and in some others, distributions have penetrated slightly to the opposite side only in a few small areas (e.g., *Oedura lesueurii*, *Oedura tryoni*,

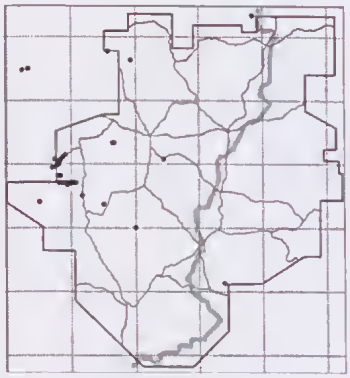

FIG. 3. *Amphibolurus burnsi*

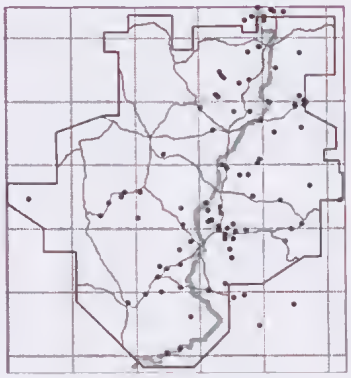

FIG. 4. *Amphibolurus muricatus*

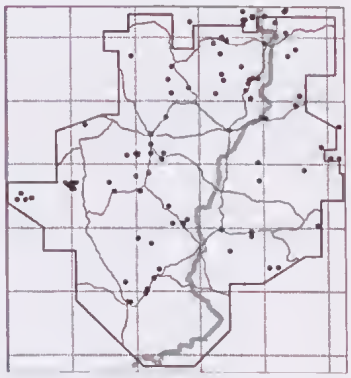

FIG. 5. *Amphibolurus nobbi*

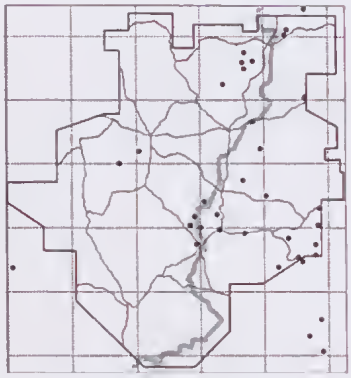

FIG. 6. *Physignathus lesueurii*

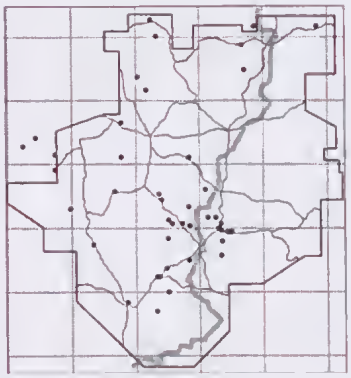

FIG. 7. *Pogona barbata*

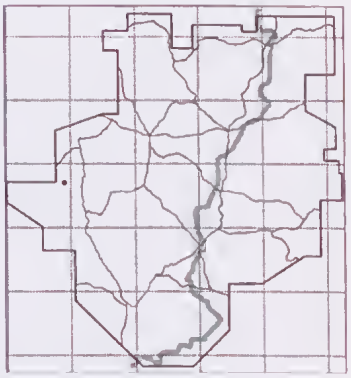

FIG. 8. *Pogona vitticeps*

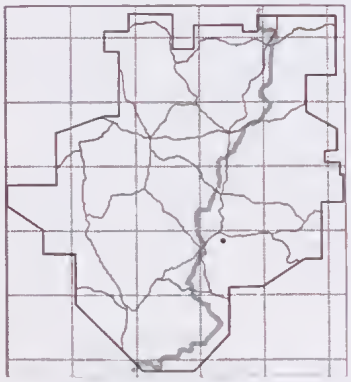

FIG. 9. *Tympanocryptis lineata*

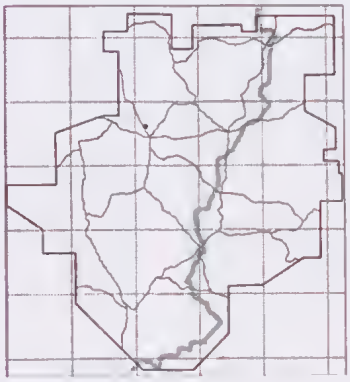

FIG. 10. *Tympanocryptis tetraporophora*

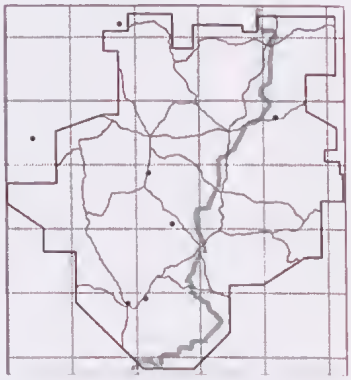

FIG. 11. *Varanus gouldii*

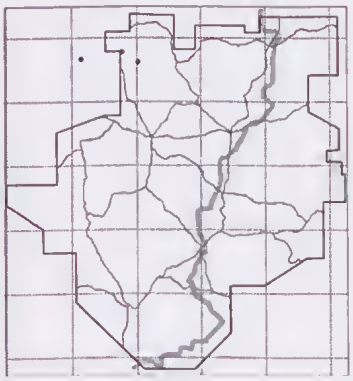

FIG. 12. *Varanus tristis*

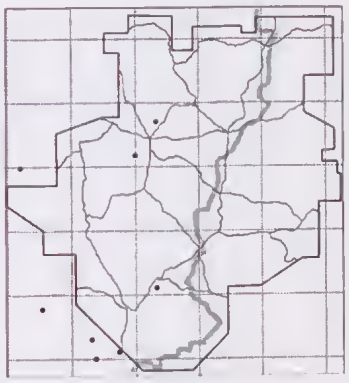

FIG. 13. *Varanus varius*

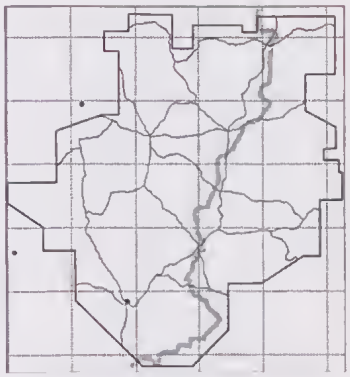

FIG. 14. *Diplodactylus intermedius*

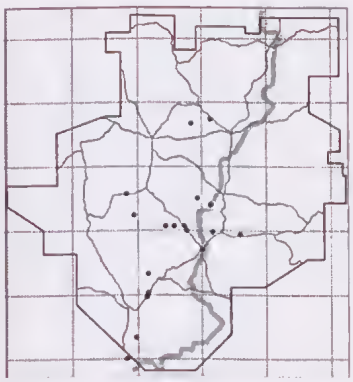

FIG. 15. *Diplodactylus vittatus*

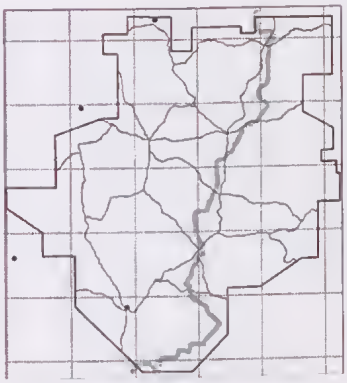

FIG. 16. *Diplodactylus williamsi*

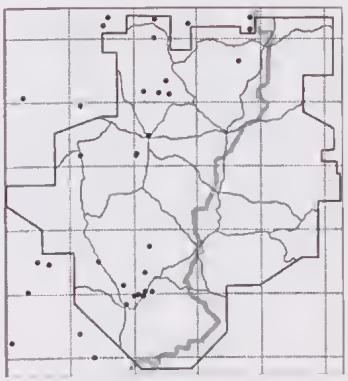

FIG. 17. *Gehyra dubia*

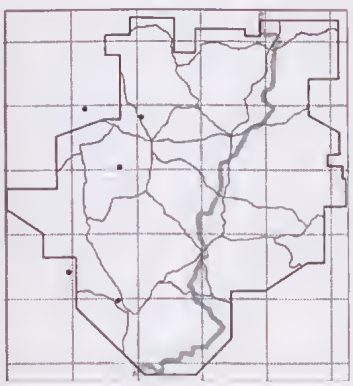

FIG. 18. *Gehyra variegata*

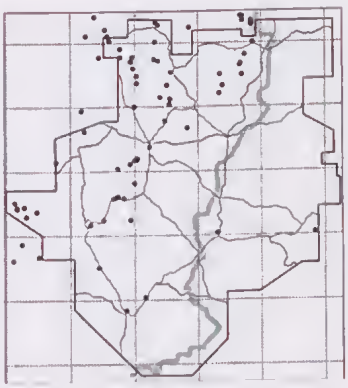

FIG. 19. *Heteronotia binoei*

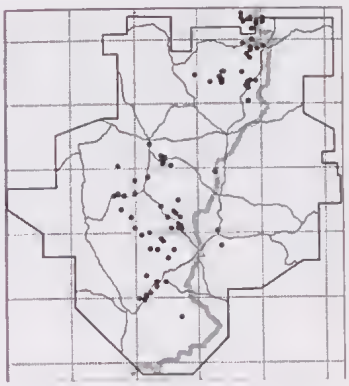

FIG. 20. *Oedura lesueurii*

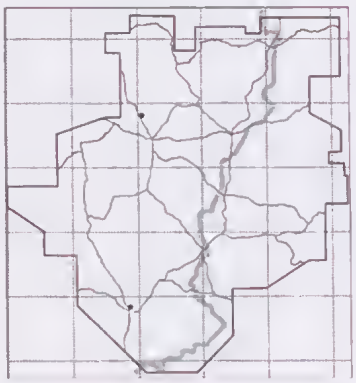

FIG. 21. *Oedura monilis*

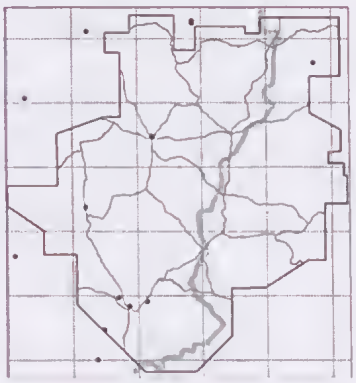

FIG. 22. *Oedura robusta*

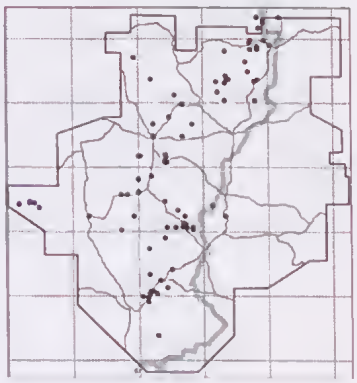

FIG. 23. *Oedura tryoni*

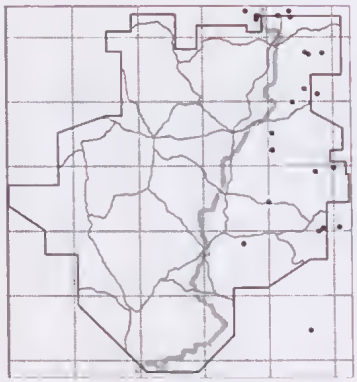

FIG. 24. *Saltuarius swaini*

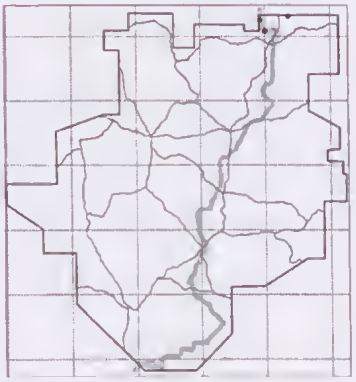

FIG. 25. *Saltuarius wyberba*

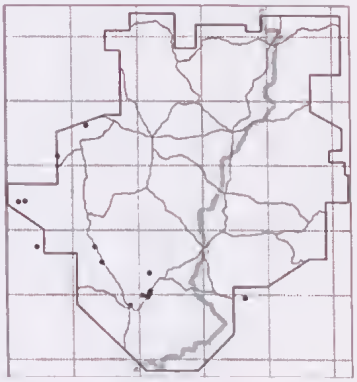

FIG. 26. *Underwoodisaurus milii*

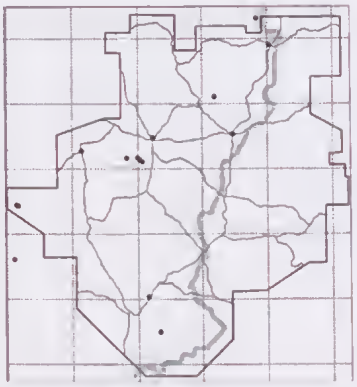

FIG. 27. *Underwoodisaurus sphyrurus*

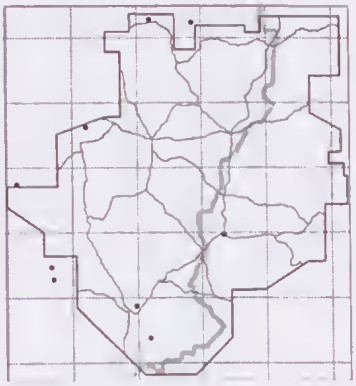

FIG. 28. *Delma plebeia*

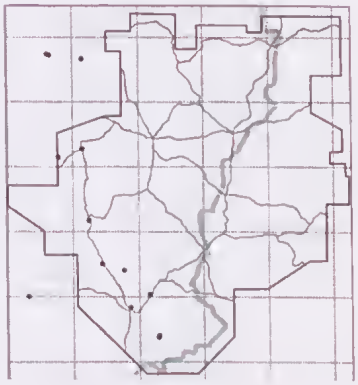

FIG. 29. *Delma tincta*

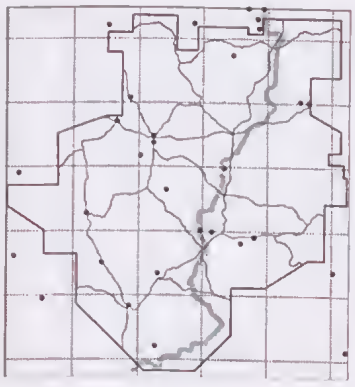

FIG. 30. *Lialis burtonis*

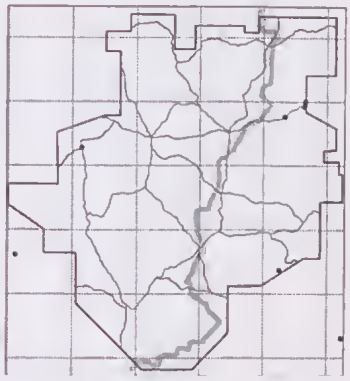

FIG. 31. *Pygopus lepidopodus*

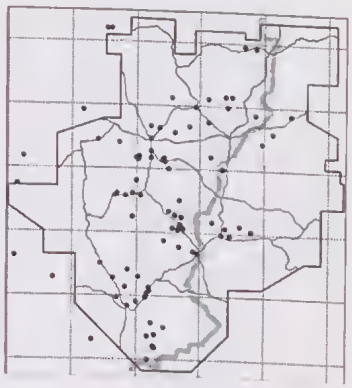

FIG. 32. *Anomalopus leuckartii*

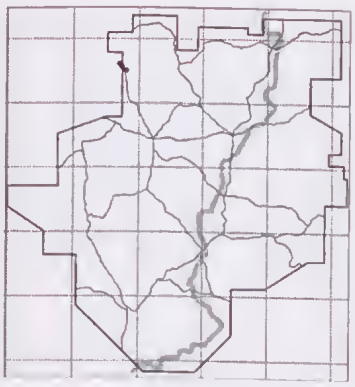

FIG. 33. *Anomalopus mackayi*

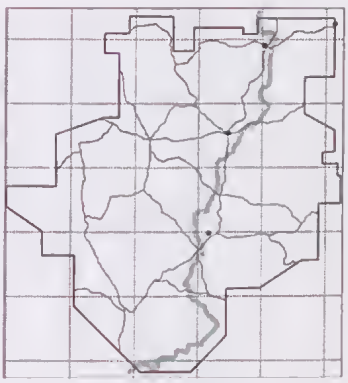

FIG. 34. *Anomalopus verreauxi*

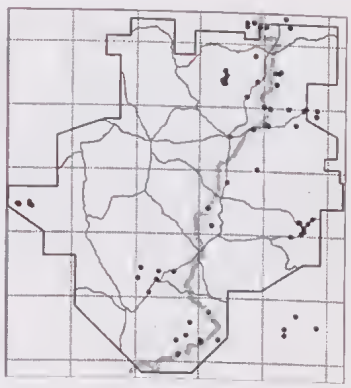

FIG. 35. *Bassiana platynota*

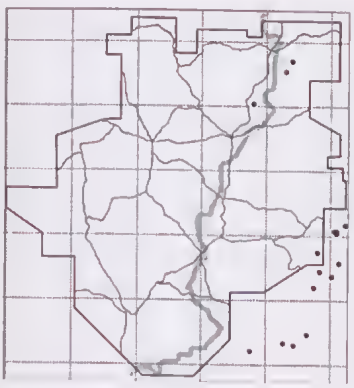

FIG. 36. *Calyptotis ruficauda*

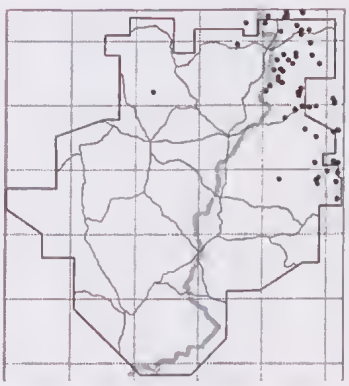

FIG. 37. *Calyptotis scutirostrum*

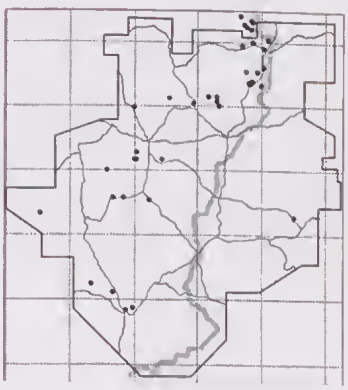

FIG. 38. *Carlia tetradactyla*

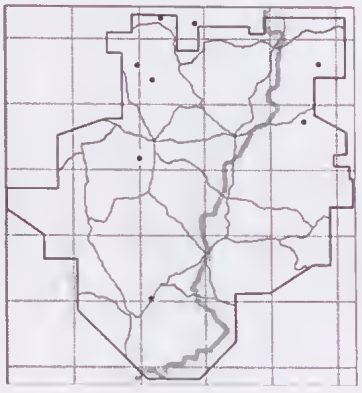

FIG. 39. *Carlia vivax*

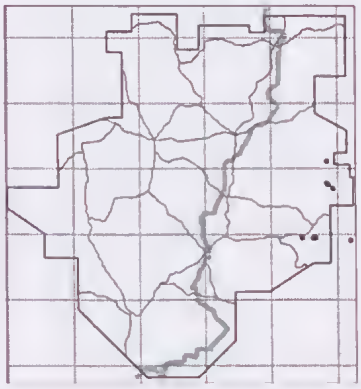

FIG. 40. *Cautula zia*

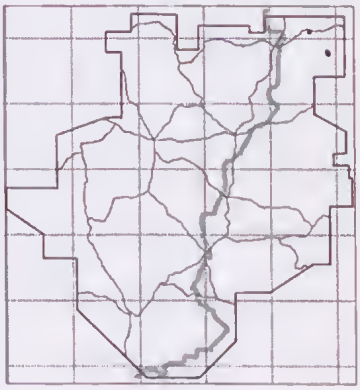

FIG. 41. *Coeranoscincus reticulatus*

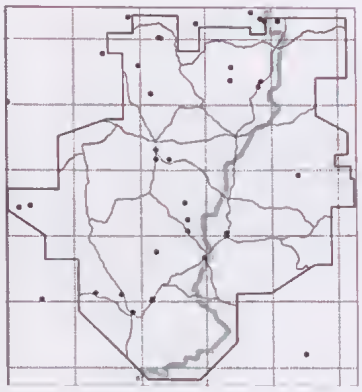

FIG. 42. *Cryptoblepharus virgatus*

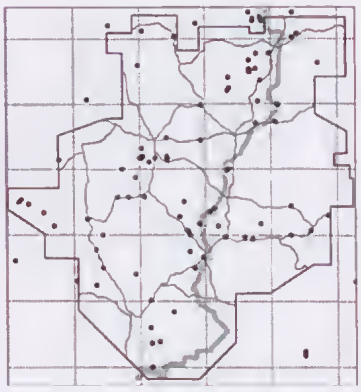

FIG. 43. *Ctenotus robustus*

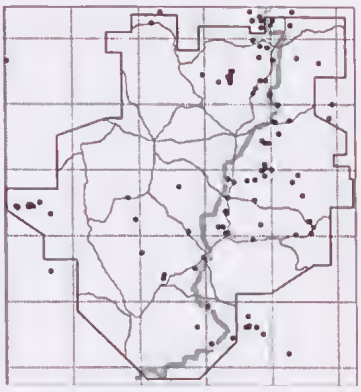

FIG. 44. *Ctenotus taeniolatus*

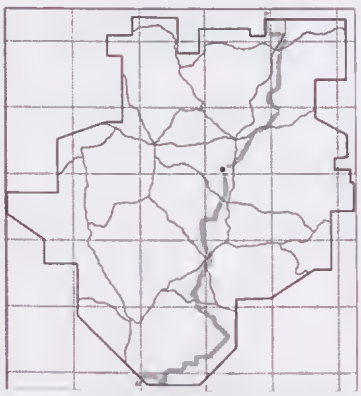

FIG. 45. *Cyclodomorphus michaeli*

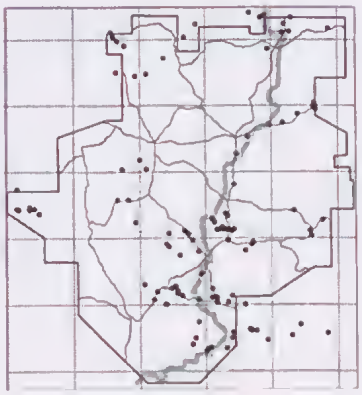

FIG. 46. *Egernia cunninghami*

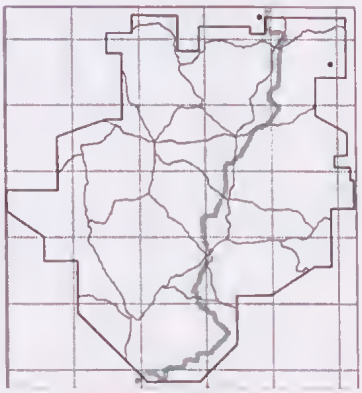

FIG. 47. *Egernia frerei*

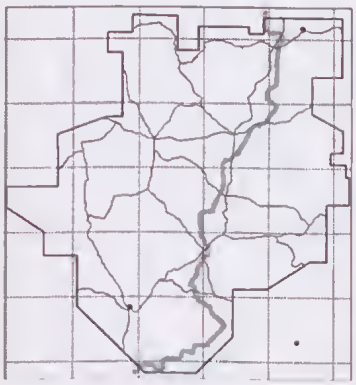

FIG. 48. *Egernia major*

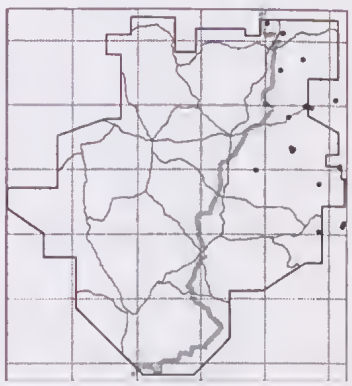

FIG. 49. *Egernia mcpheei*

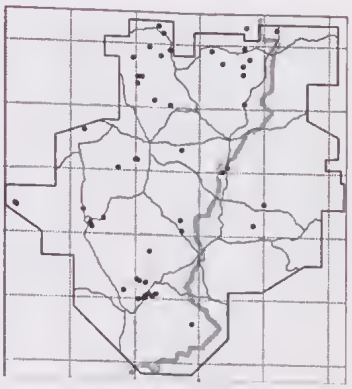

FIG. 50. *Egernia modesta*

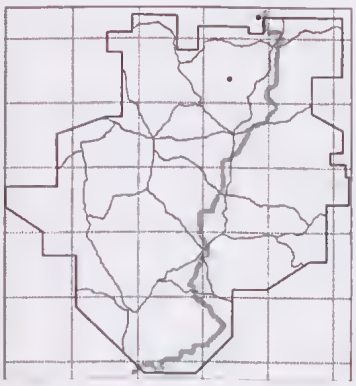

FIG. 51. *Egernia saxatilis*

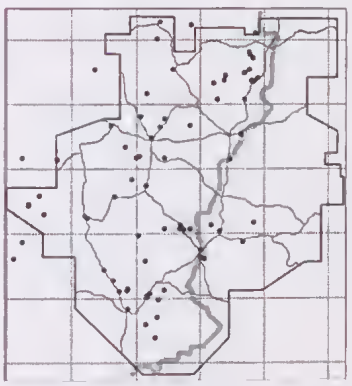

FIG. 52. *Egernia striolata*

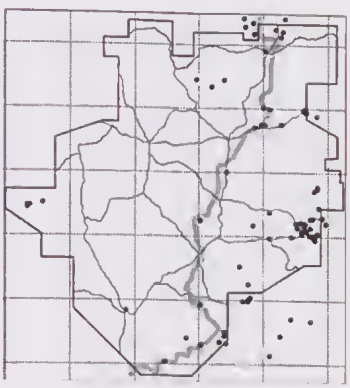

FIG. 53. *Egernia whitii*

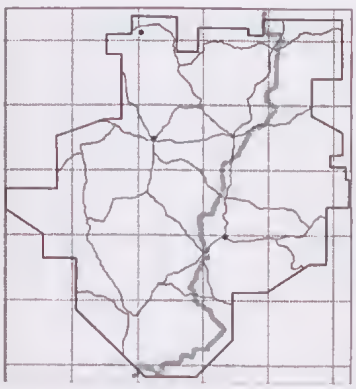

FIG. 54. *Eremiascincus richardsoni*

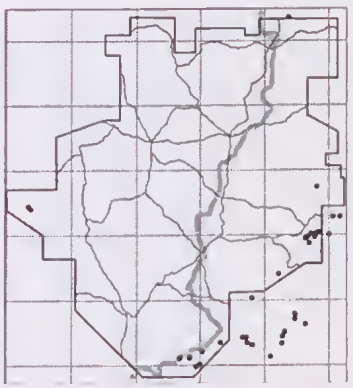

FIG. 55. *Eulamprus heatwolei*

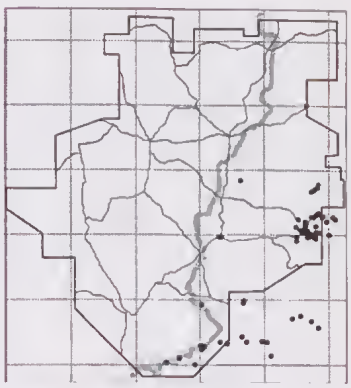

FIG. 56. *Eulamprus kosciuskoi*

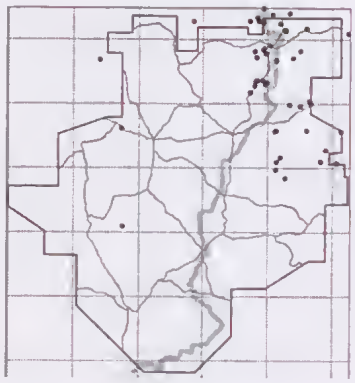

FIG. 57. *Eulamprus martini*

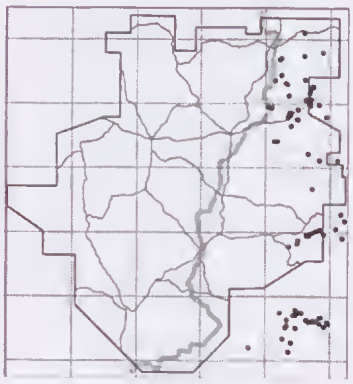

FIG. 58. *Eulamprus murrayi*

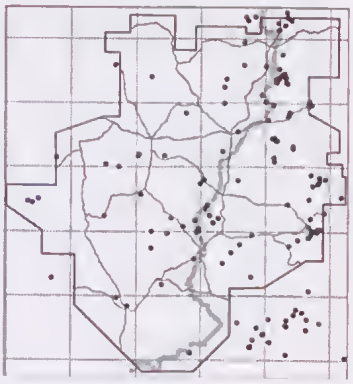

FIG. 59. *Eulamprus quoyii*

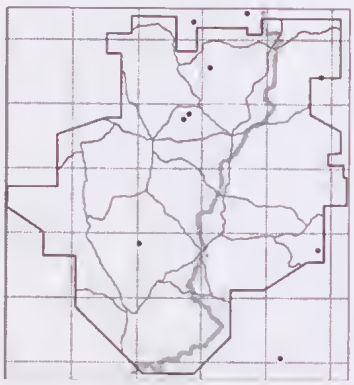

FIG. 60. *Eulamprus tenuis*

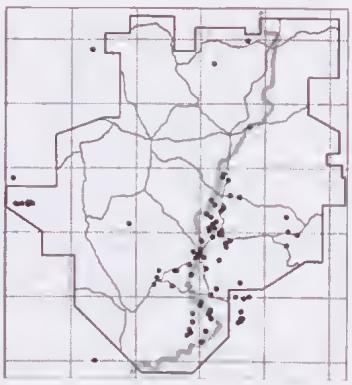

FIG. 61. *Hemiergis decresiensis*

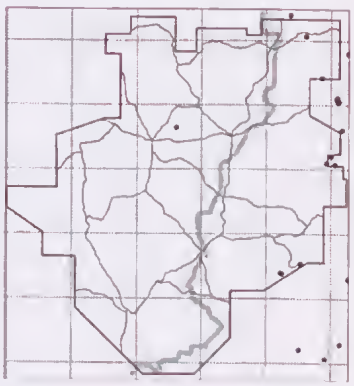

FIG. 62. *Lampropholis amicula*

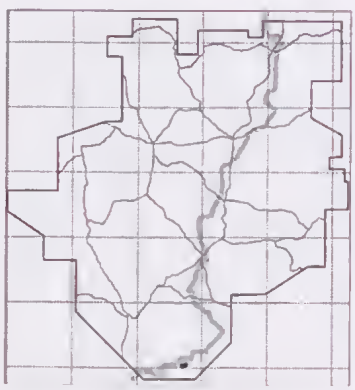

FIG. 63. *Lampropholis caligula*

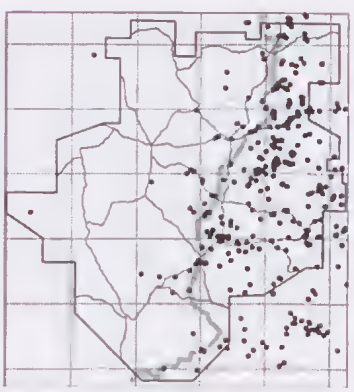

FIG. 64. *Lampropholis delicata*

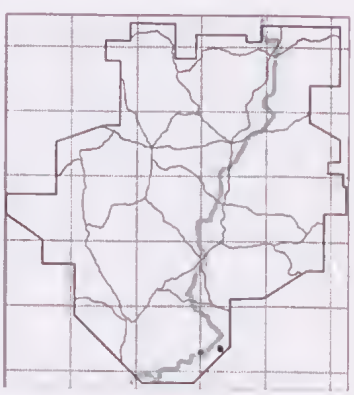

FIG. 65. *Lampropholis elongata*

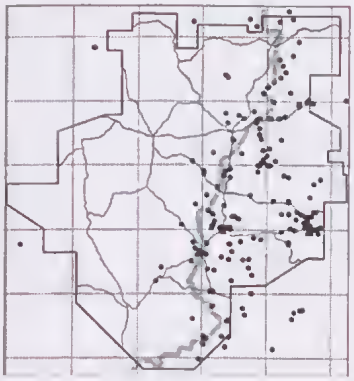

FIG. 66. *Lampropholis guichenoti*

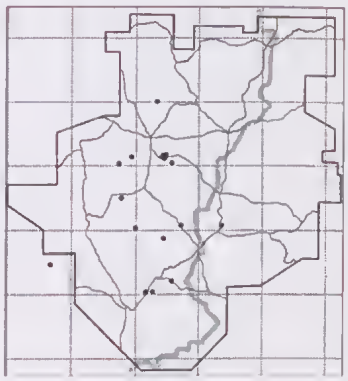

FIG. 67. *Lerista bougainvillii*

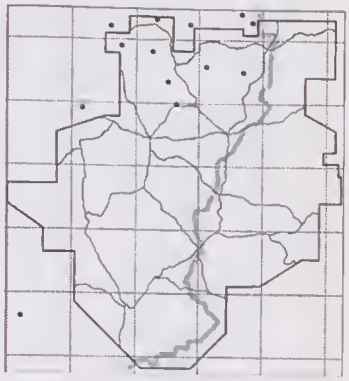

FIG. 68. *Lerista muelleri*

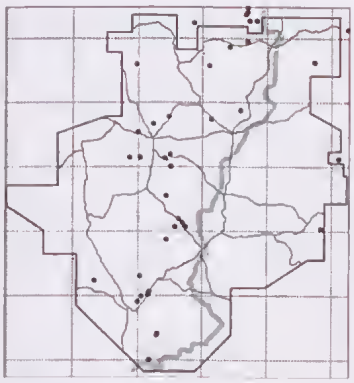

FIG. 69. *Lygisaurus foliorum*

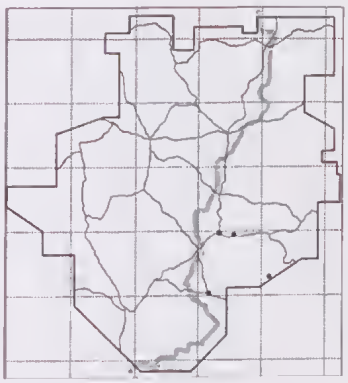

FIG. 70. *Menetia greyii*

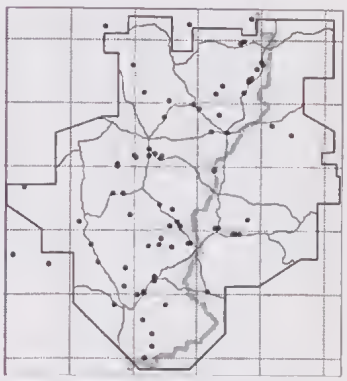

FIG. 71. *Morethia boulengeri*

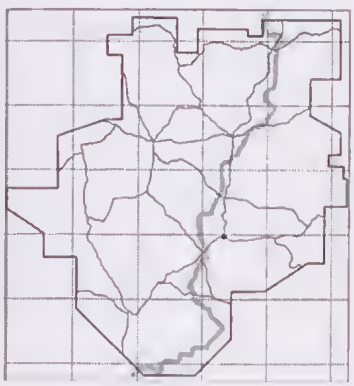

FIG. 72. *Nannoscincus maccoyi*

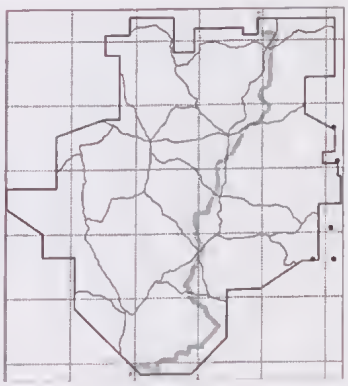

FIG. 73. *Ophioscincus truncatus*

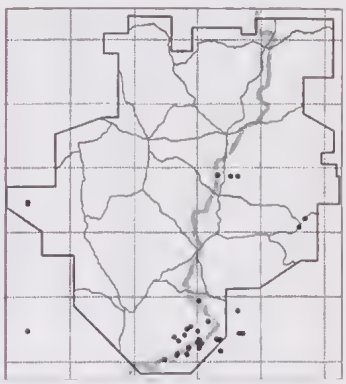

FIG. 74. *Pseudemoia pagenstecheri*

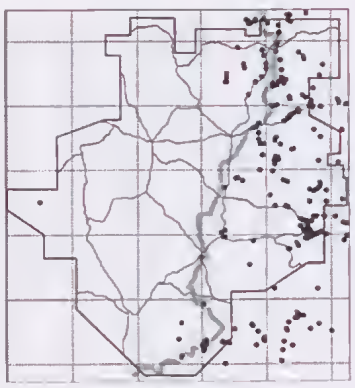

FIG. 75. *Saiphos equalis*

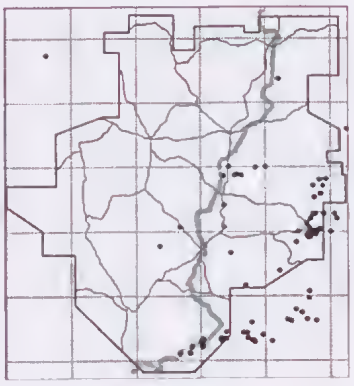

FIG. 76. *Saproscincus mustelina*

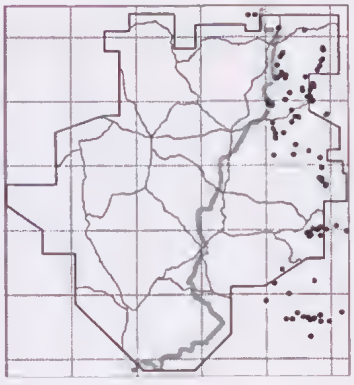

FIG. 77. *Saproscincus rosei*

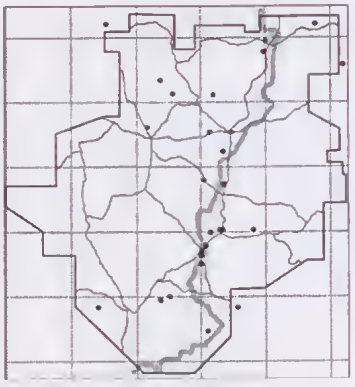

FIG. 78. *Tiliqua scincoides*

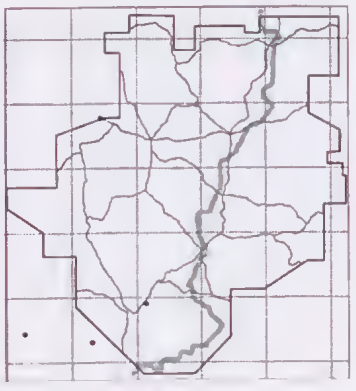

FIG. 79. *Ramphotyphlops bituberculatus*

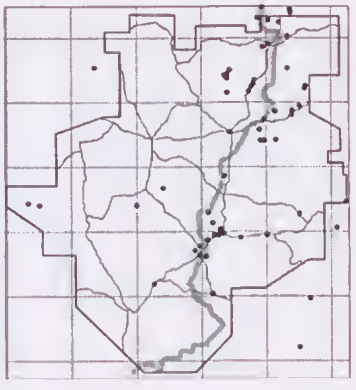

FIG. 80. *Ramphotyphlops nigrescens*

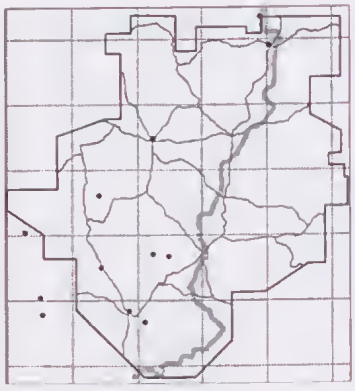

FIG. 81. *Ramphotyphlops proximus*

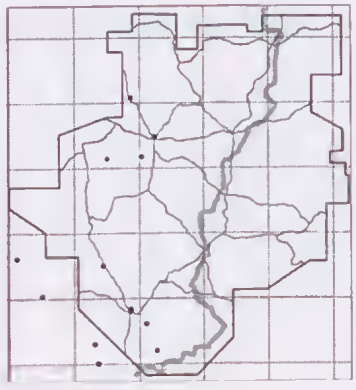

FIG. 82. *Ramphotyphlops wiedii*

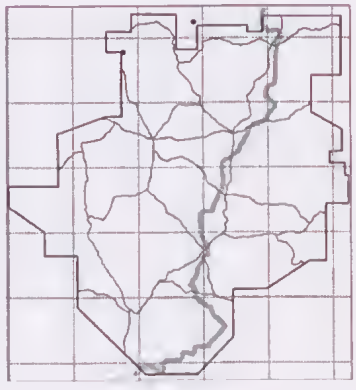

FIG. 83. *Antaresia maculosa*

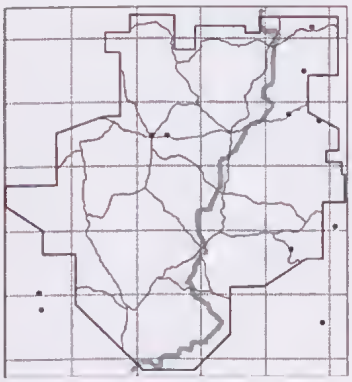

FIG. 84. *Morelia spilota*

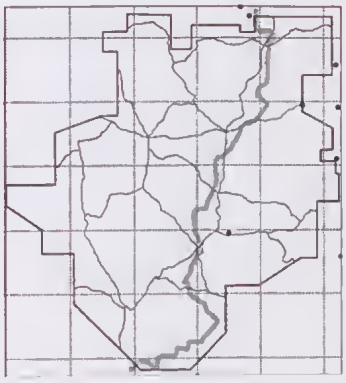

FIG. 85. *Boiga irregularis*

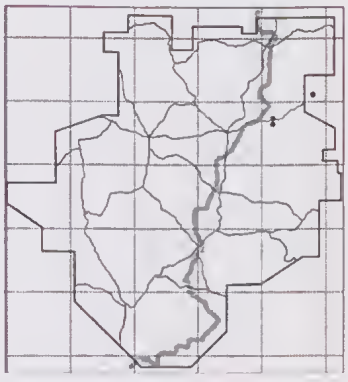

FIG. 86. *Dendrelaphis punctulata*

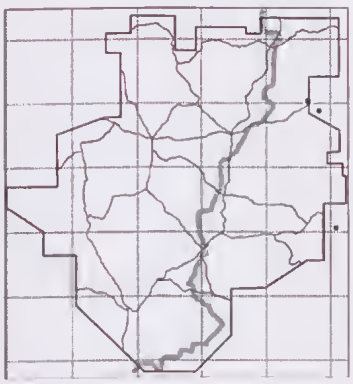

FIG. 87. *Acanthophis antarcticus*

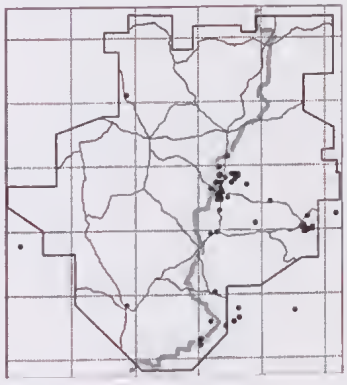

FIG. 88. *Austrelaps ramsayi*

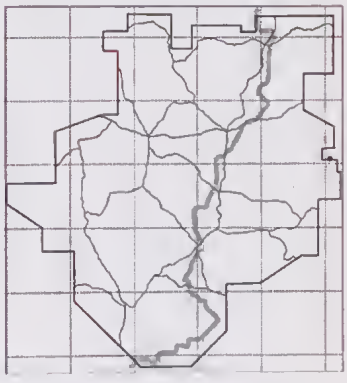

FIG. 89. *Cacophis harriettae*

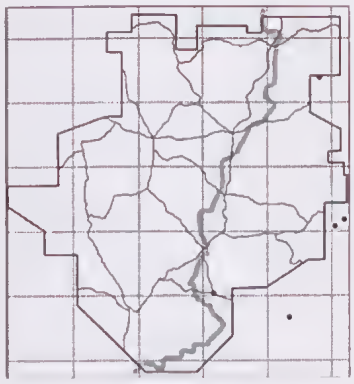

FIG. 90. *Cacophis krefftii*

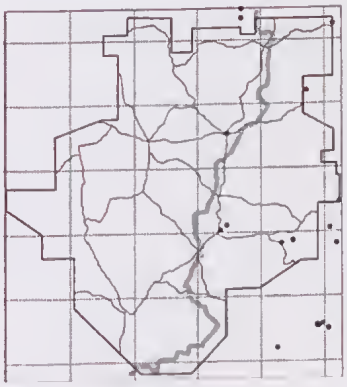

FIG. 91. *Cacophis squamulosus*

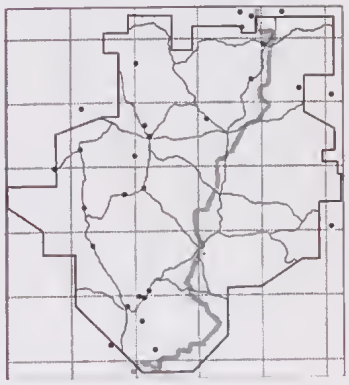

FIG. 92. *Demansia psammophis*

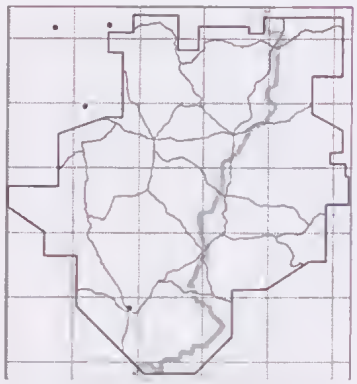

FIG. 93. *Denisonia devisi*

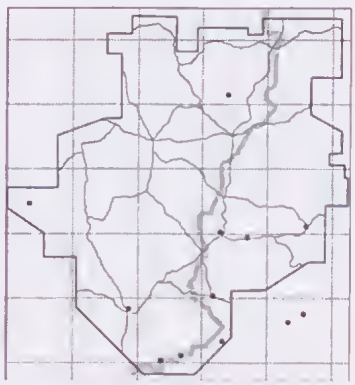

FIG. 94. *Drysdalia coronoides*

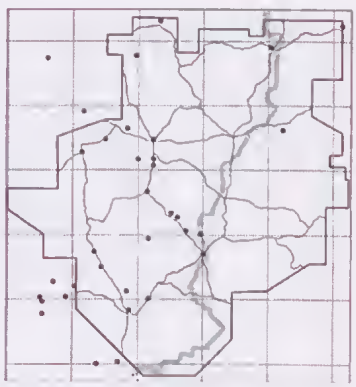

FIG. 95. *Furina diadema*

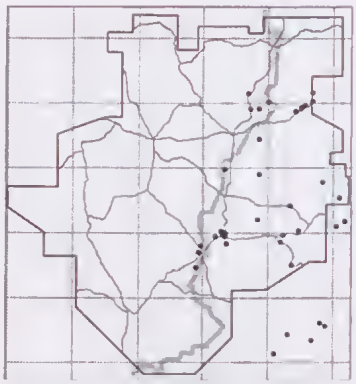

FIG. 96. *Hemiaspis signata*

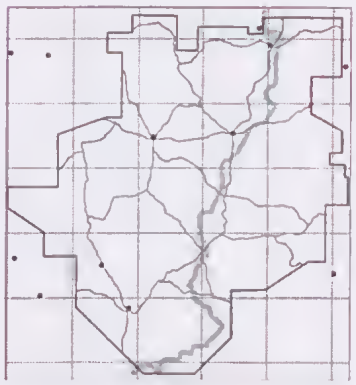

FIG. 97. *Hoplocephalus bitorquatus*

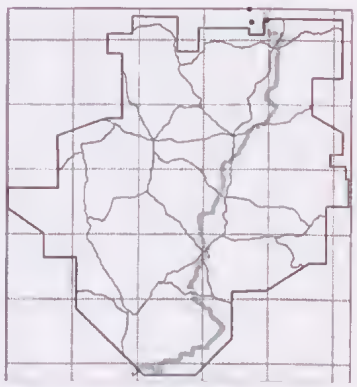

FIG. 98. *Hoplocephalus stephensii*

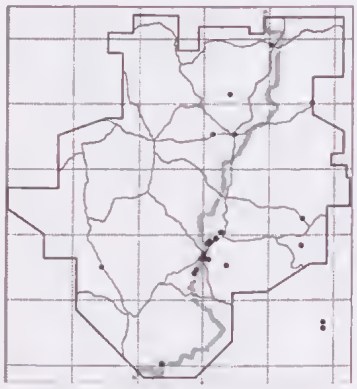

FIG. 99. *Notechis scutatus*

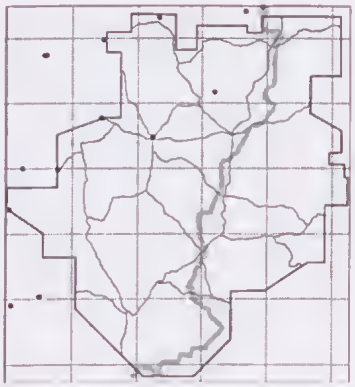

FIG. 100. *Pseudechis guttatus*

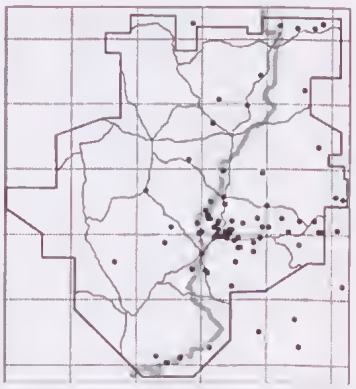

FIG. 101. *Pseudechis porphyriacus*

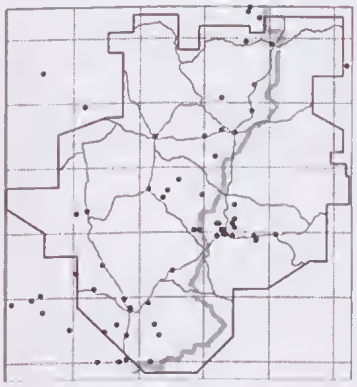

FIG. 102. *Pseudonaja textilis*

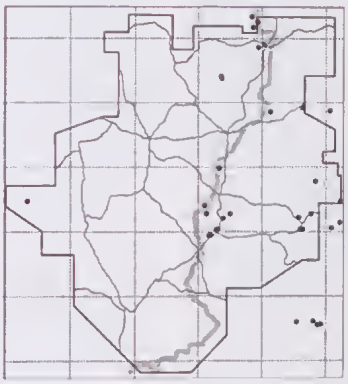

FIG. 103. *Rhinoplocephalus nigrescens*

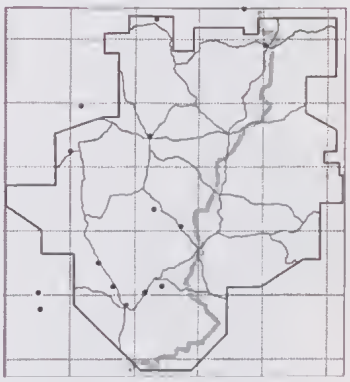

FIG. 104. *Simoselaps australis*

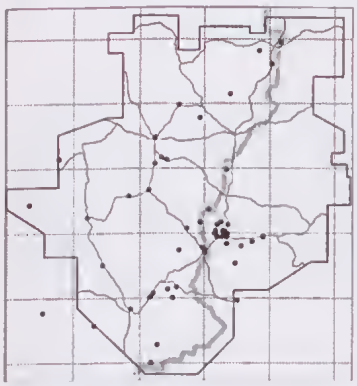

FIG. 105. *Suta dwyeri*

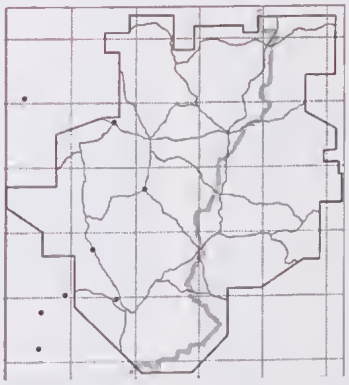

FIG. 106. *Suta suta*

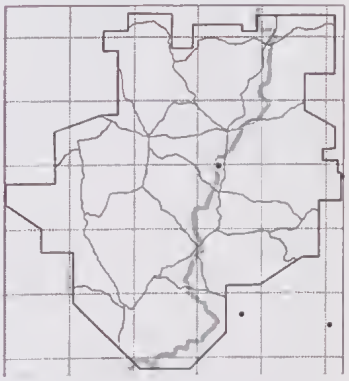

FIG. 107. *Tropidechis carinatus*

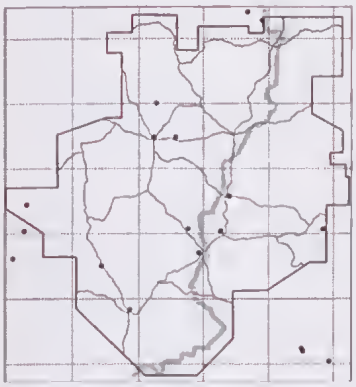

FIG. 108. *Vermicella annulata*

Egernia modesta, *Hemiaspis signata*). However, the topography is not severe on the continental divide and it is unlikely to constitute a physical barrier to dispersal for many species. For a number of species, the boundary of the geographic range lies considerably to one side or the other of the continental divide (e.g., *Anomalopus leuckartii*, *Bassiana platynota*, *Lamprophlolis delicata*, *Lamprophlolis guichenoti*, *Pseudechis porphyriacus*). In such cases, it is likely that distribution is limited by one or more climatic parameters with an east-west gradient (see below), rather than by the Great Dividing Range itself.

Some of the eastern species certainly can disperse beyond the Great Dividing Range as there are outlier populations on the western edge of the study area at Mt Kaputar, where elevation, rainfall and vegetation parallel those on the eastern side, but differ from those of the western areas surrounding the mountain. Such outliers are: *Bassiana platynota*, *Ctenotus taeniolatus*, *Egernia cunninghami*, *Egernia whitii*, *Eulamprus heatwolei*, *Hemiergis decresiensis*, *Lamprophlolis delicata*, *Pseudemoia pagenstecheri* and *Rhinoplocephalus nigrescens*. Conversely, a few predominantly western species (e.g, *Heteronotia binoei*) are found in a few localities in the east.

A number of the species that are predominantly western within the confines of New England are absent or uncommon in eastern New England because of their exclusion from the wetter forests of that region; beyond that gap their ranges do extend eastward, often to the coast. Examples are *Oedura robusta*, *Lygisaurus foliorum*, *Tiliqua scincoides*, *Ramphotyphlops wiedii*, *Demansia psammophis*, *Furina diadema*, *Pseudonaja textilis* and *Simoselaps australis*.

There are slightly more species with a predominantly western distribution (40%) than a predominantly eastern one (30%). The difference may be even more disparate than these figures suggest, as there are a number of western species, e.g., *Trachydosaurus rugosus*, *Pseudechis australis*, that have been found near, but not inside, the western boundary of New England. With further collecting, or upon completion of some of the surveys still in progress, the ranges of some of these will likely be found to extend into New England.

It should also be noted that gorges and river valleys permit the penetration of coastal species into New England e.g. *Boiga irregularis* (Webber & Heatole, 1991).

Different taxa vary in regard to east-west distributional patterns. The geckos (13 species western, 2 species eastern), pygopodids (2 w, 0 e), varanids (2 w, 0 e), agamids (5 w, 1 e), typhlophids (3 w, 0 e) and boids (1 w, 0 e) are mainly western rather than eastern, whereas the reverse is true of the skinks (24 species eastern, 12 species western), elapids (11 e, 7 w) and colubrids (2 e, 0 w).

NORTHERN VERSUS SOUTHERN DISTRIBUTIONS. The north-south axis does not feature prominently in the distribution of squamates in New England. The northerly distributed species occur on only one side or other of the Great Dividing Range and hence represent subsets of the eastern (8 species) or western (4 species) groups, but whose southern limits of distribution are reached in New England. There are no species restricted to the north that range widely from east to west in that region.

There are just two species in New England that span New England from east to west but primarily in the south; these are *Pseudemoia pagenstecheri* (Fig. 74) and *Tympanocryptis diemensis* (Swan, 1990). There are six species from only the southeastern quadrant and four from only the southwestern one; these were considered subgroups of the eastern and western groups.

'CENTRAL' DISTRIBUTION. There was no species with a strictly central distribution. However, *Hemiergis decresiensis* was predominantly central in that it was represented by many localities in the central region, along the continental divide and immediately adjacent to it; beyond that area it was widespread (and was listed as such for statistical purposes), but only at scattered localities.

The only other species known only from central locations were represented by so few records that their distribution within New England could not be interpreted.

INFREQUENTLY ENCOUNTERED. A salient aspect of the New England reptilian fauna is the large number of species that were recorded from only a small number of localities ('R' in Table 1). In many cases, supplementation by the additional localities mapped by Swan (1990) allowed allocation of these species to one of the distributional categories mentioned above. The remaining (4 species) were represented by only one locality in New England and supplementary

information was not available to aid in interpretation of their local distributional pattern. For example, *Nannoscincus maccoyi* (Fig. 72) was found at only one locality, southeast of the center of New England. This is a considerable range extension as formerly it was not known north of Sydney (Swan, 1990). It is likely that the ranges of such species will be extended with further information, or these localities shown to be outliers.

Some of these R species may be rare; in other cases they may be more common than suggested by their frequency in collections because they are secretive and therefore less subject to being found. Gibbons et al. (1997) noted that over a long period of collecting, the known extent of distributions tend to increase remarkably and species' ranges often are much broader than indicated by less intensive collecting.

RELATION OF DISTRIBUTION TO ENVIRONMENTAL CONDITIONS

In the following account, the range of conditions under which the various species are found within New England is given. Outside of New England some of these species may extend into areas with environments beyond the limits encountered within the study area. Where correlations are made between distributional patterns and particular levels of environmental features, the relationship is referable only to the New England area, not to the geographic range of a species as a whole.

ELEVATION. The lowest elevations (below 400m) are located at the edges of the region in the northwest, southwest and southeast. These slope upward to the New England plateau of 800-1200m in the eastern half of the region with isolated areas up to more than 1400 m, especially near the southern boundary and from the east-central region to the eastern border (Fig. 109).

The frequency of collecting localities had a unimodal distribution skewed toward the middle elevations. The greatest frequency of occurrence was at 100-1100m and the second greatest at 900-1000m. From these values there was a progressive decrease toward the extremes of the range of elevations.

All 26 species for which there were sufficient data for statistical testing of distributions against category of elevation were found at a wide variety of elevations. Of these, seven were distributed randomly with respect to elevation, seven were over-represented at the lower

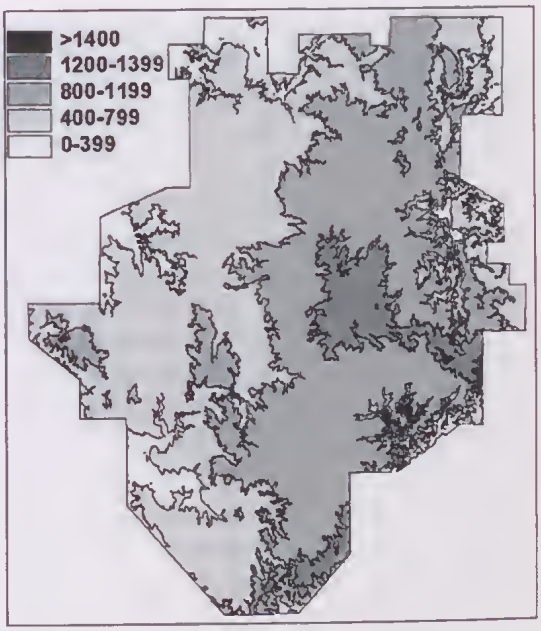

FIG. 109. Elevations (m) of the study area. Data from the original Digital Elevation Model (DEM) supplied by NSW Land and Property Information (NSW LPI), 1997.

elevations, two at the middle elevations, three at middle to high elevations and seven at the higher elevations (Table 3).

CLIMATE. *Rainfall*. A map of New England with a rough approximation of the isohyets was presented in the first paper of this series (Heatwole & Simpson, 1986). A more detailed map showing the distribution of rainfall was used for the present analyses (Fig. 110). The western and northwestern parts of the region have relatively low mean annual rainfall (mostly 800mm or less) increasing toward the east. The eastern border is especially wet with rainfall >1700mm per annum occurring just to the east and southeast of the designated boundary.

The collecting sites were distributed unimodally with respect to rainfall categories, but skewed toward the lower levels of precipitation. Almost a third of the sites were in areas characterised by 700-800 mm of rain per annum, and the next highest frequency was in the 800-900mm category. All other categories individually contained <13% of the collecting sites.

Of the 14 species for which there were sufficient data for statistical testing, all occurred over most of the spectrum of rainfall values and two species were randomly distributed with

TABLE 3. Distribution of species or reptiles in relation to various environmental parameters. R=random; — indicates that expectation was lower than 5 in the smallest category and therefore not testable statistically. * 'Other' refers to minor soil or rock types lumped into one category for statistical testing; CP=Chocolate Prairie; RP=Red Podzolic; YS/YP=Yellow Sol/Yellow Pod; YP/GP=Yellow Pod/Gley Pod.

Species	Elevation	Rainfall	Coldest Month Minimum Temp	Hottest Month Maximum Temp	Vegetation	Soil Type	Rock Type
Heteronotia binoei	Lower	—	—	26°-32°	—	—	R
Oedura lesueurii	Middle	Low to Medium	-4° to 1°	25°-28°	—	YS/YP;YP.GP	Granite
Oedura tryoni	Lower	Low to Medium	-4° to 1°	26°-32°	—	YS/YP;YP/GP	Granite; Other*
Amphibolurus nobbi	Lower	Low to Medium	R	26°-32°	—	YP/GP; Other*	R
Amphibolurus muricatus	R	R	-4° to -1°	R	—	R	R
Anomalopus leuckartii	Lower	Low	R	26°-32°	—	Other*	Granite, Other*
Bassiana platynota	Higher	—	—	—	—	—	—
Calyptotis scutirostrum	R	—	—	—	—	—	—
Ctenotus robustus	Lower	Low	—	26°-32°	—	—	R
Ctenotus taeniolatus	Higher	—	—	R	—	—	—
Egernia cunninghami	R	R	R	R	—	R	Granite
Egernia striolata	Lower	—	—	26°-32°	—	—	R
Egernia whitii	Higher	—	—	—	—	—	—
Eulamprus murrayi	Middle	—	—	—	—	—	—
Eulamprus quoyii	R	Medium to High	0°	R	—	—	R
Hemiergis decresiensis	Higher	Low	-4° to -1°	24°	—	RP; YS/YP; Other*	Basic Igneus
Lampropholis delicata	Middle to High	Medium to High	0° to 6°	21-25°	Woodland; Dry Forest; Wet Forest	RP	R
Lampropholis guichenoti	Middle to High	Medium to High	0°	21°-25°	Wet Forest	RP	R
Morethia boulengeri	Lower	Low to Medium	—	R	—	—	R
Saiphos equalis	Middle to High	Medium to High	0°	21°-25°	Wet Forest	RP	Sedimentary
Saproscincus rosei	R	—	—	—	—	—	R
Ramphotyphlops nigrescens	Higher	—	—	24°-25°	—	—	Basic Igneus; Granite; Other*
Austrelaps romsoyi	Higher	—	—	—	—	—	—
Austrelaps superbus	—	—	—	—	—	—	Basic Igneus
Pseudechis porphyriacus	Higher	Low to Medium	-1°	21°-24°	—	YS/YP; CP; Other*	Sedimentary; Basic Igneus
Pseudonaja textilis	R	—	—	R	—	—	R
Suta dwyeri	R	—	—	R	—	—	R

respect to rainfall (Table 3). However, three species were over-represented in areas of low rainfall, five species were found more often than expected on the basis of chance in localities of low to medium rainfall, and four species were proportionately more common in places with medium to high rainfall.

Temperature. Heatwole & Simpson (1986) presented maps (based on Lea et al., 1977 'An Atlas of New England') of the isotherms of the mean daily maxima and minima for the months of July and January, and Heatwole et al. (1995) reproduced one of them (mean daily minimum for July). In general, the central part of the region is the coldest with higher isotherms concentrically arranged toward the periphery.

The present analysis was based on the mean daily minimum of the coldest month (range -4 to

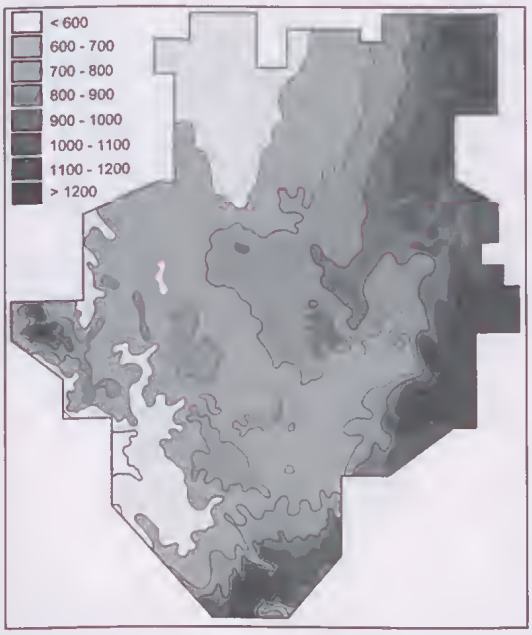

FIG. 110. Mean annual rainfall (mm) of the study area. Original DEM supplied by NSW LPI. Mean potential rainfall data derived from ESOCLIM program which was supplied by CRES at National University, 1997.

6°C) (Fig. 111) and mean daily maximum of the hottest month (range within the area of 12°C to 32°C) (Fig. 112).

The mean daily minima of the coldest month were unimodally distributed with a peak at and just below freezing, gradually descending toward the higher and lower values. Intervals of mean daily minima of 2°C or above accounted for only slightly more than 9% of the collecting sites and those of 2°C or above for only about 14%.

Of the twelve species for which statistical analysis was feasible, three showed random distribution with regard to levels of mean daily minimum temperature of the coldest month (Table 3). The remainder, while found over most of the spectrum of minimum temperatures, statistically favoured certain levels. Four species tended to occur more often than expected in the coldest localities, four at intermediate localities (near zero), and one was enigmatic, being found more often than expected by chance over a wide range of the higher temperatures.

The mean daily maximum temperature of the hottest month showed a bimodal frequency distribution with one peak at 24°C (20.6% of the collecting sites) and 25°C (21.4%) and the other at 28°C (12.1%); all other temperature intervals individually accounted for <10% of the sites.

Of the 20 species for which statistical testing could be conducted, seven were shown to be distributed at random with respect to mean daily maximum temperature for the hottest month (Table 3). Four species were over-represented in the thermal categories in the range of 21°-24°C or 21°-25°C, two in the ranges of 24°C or 24°-25°C, and seven in various ranges of categories from 25° C and higher.

VEGETATION. The New England area is devoted to the pastoral industry and consequently is highly modified by human activity. Accordingly, many of the collecting sites occurred on cleared land (45%), with disturbed remnants accounting for an additional 11% of the localities. The forest types containing the greatest frequency of occurrence of collecting sites were Dry Forest Complex (19%) and Dry Open Forest (15%); all other vegetation types individually contained 11% of the sites (Fig. 113).

Each of the previous papers in this series has used a different classification of vegetation or land-use. The present analysis is based on a modification of the classification of vegetation systems for northeastern New South Wales (NSW National Parks and Wildlife Service, 1994).

Only three species could be tested because of the small areas occupied by wet forests and the statistical limitations this imposed. *Saiphos equalis* and *Lampropholis guichenoti* were found in wet forest significantly more often than expected at random, whereas *Lampropholis delicata* was over-represented in woodlands and in both dry and wet forests (Table 3).

SOIL TYPE. The soil types (Fig. 114) accounting for the greatest number of collecting localities were Yellow Pod/Grey Pod (24% of the sites), Red Podzolic (21%) and Yellow Sol/Yellow Pod (19%); the other 15 soil types each accounted for <10% of the collecting localities and collectively for 36%.

Eleven species were tested against the distribution of soil types. Of these, two were distributed randomly with respect to soil type (Table 3), three were found oftener than expected by chance on red podzolic soils, and five were over-represented on more than one soil type, but always involving yellow sol/yellow pod and/or yellow pod/gley pod soils in combination with others.

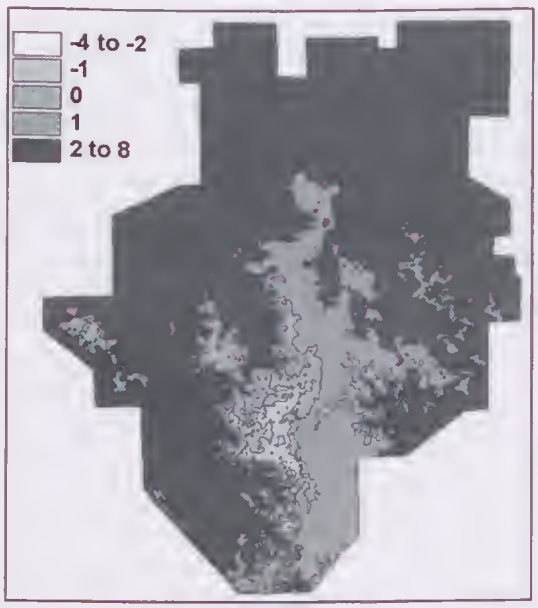

FIG. 111. Mean daily minimum temperatures(°C) of the coldest month (July) in the study area. Original DEM supplied by NSW LPI. Mean potential temperature data derived from ESOCLIM program which was supplied by CRES at National University, 1997.

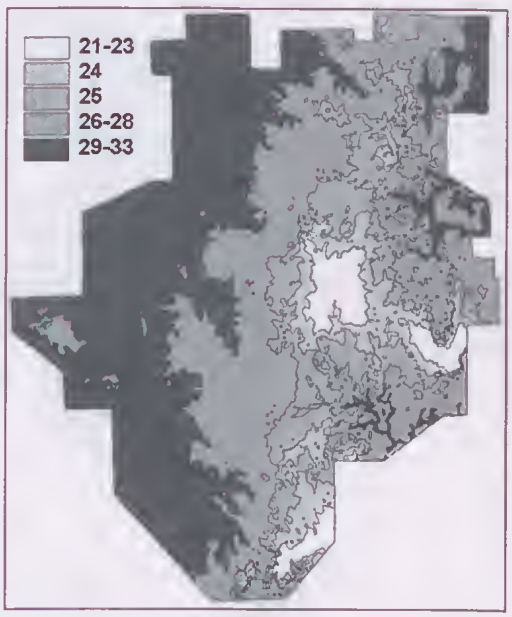

FIG. 112. Mean daily temperatures (°C) of the warmest month (January) in the study area. Original DEM supplied by NSW LPI. Mean potential temperature derived from ESOCLIM program at National University, 1997.

ROCK TYPE. The two most abundant rock types characterising collecting sites were sedimentary rocks with low quartz (36% of the collecting sites) and granite (23%); all other rock types accounted for 13% or less of the collecting localities (Fig. 115).

Twenty-three species allowed for statistical testing of distribution against the various rock types, of which 12 were randomly distributed, five were over-represented on granite, four on basic igneous, and two on sedimentary rocks (Table 3).

Only three species could be tested against all environmental characteristics (Table 3). *Lampropholis delicata* showed random distribution only with respect to parent rock type and consequently all other characteristics may have affected its distributional patterns. It is over-represented at middle to high elevations, in woodlands and forests on red podzolic soils where there is medium to high rainfall and where mean minimum temperature of the coldest month is zero°C or above and mean maximum temperature of the hottest month is in the range of 21°-25°C. *L. delicata* does occur under other conditions, but is under-represented there and thus it would appear that this suite of environmental conditions defines the optimum habitat of this species.

Lampropholis guichenoti had an almost identical distribution to *L. delicata*. It differed only by being over-represented in a narrower range of minimum temperatures of the coldest month (0°C only, rather than the larger range 0°-6°C), in only wet forest rather than multiple kinds of forest, and by being randomly distributed relative to soil type. Despite their great similarity, and their great overlap in distribution, these two species seem to have minor differences in the biographical details.

Saiphos equalis is distributed very similarly to *L. guichenoti* except that is is over-represented on sedimentary rocks instead of being randomly distributed with respect to rock type.

Eight species could be tested against all environmental characteristics except vegetation (the characteristic allowing for the testing of the fewest number of species) (Table 3).

The most clear-cut result was for *Egernia cunninghami*, which was distributed randomly with respect to all environmental characteristics measured except it was over-represented on granite. This species inhabits crevices in exfoliating

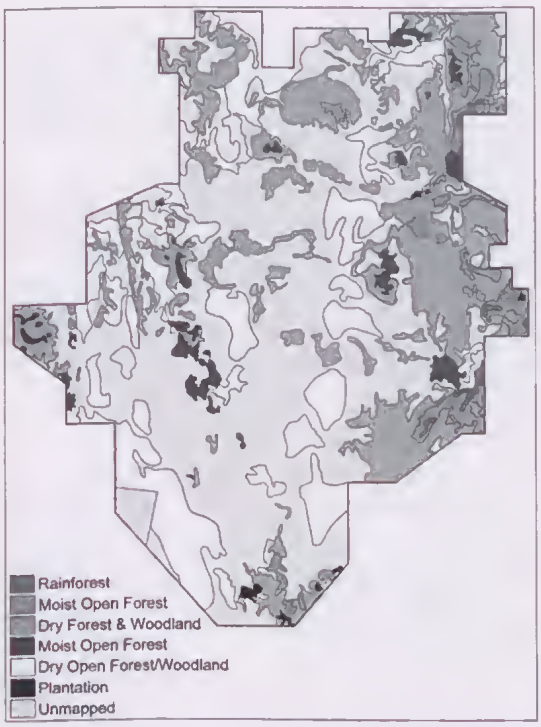

FIG. 113. Vegetation systems of the study area. Derived from broad vegetation boundaries mapped on 1:100k Landsat imagery. Mapping undertaken by NPWS in 1991.

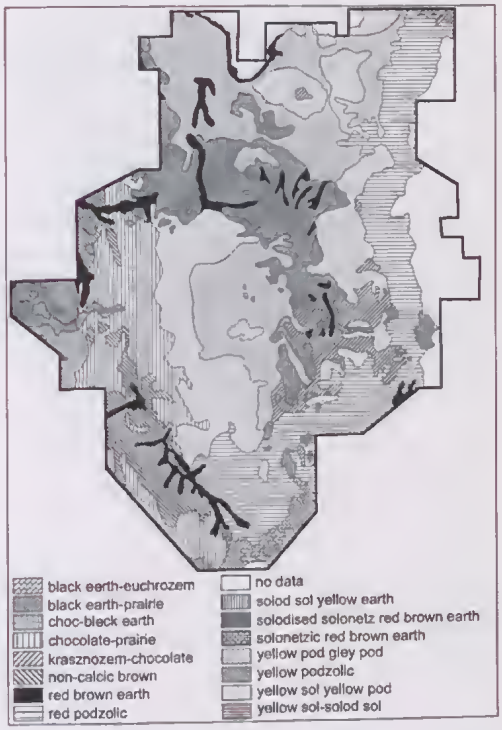

FIG. 114. Distribution of the various soil types in the study area. From the Atlas of New England (Lea et al., 1997), digitised and executed using Environmental Researeh Mapping Scheme (Ferrier, 1989), NPWS, NSW, Armidale office.

rocks throughout its range (Cogger, 2000); granite is especially prone to such structure. It is not surprising that the distribution of *E. cunninghami* is strongly related to the occurrence of this primary feature of its habitat.

Similarly, *Amphibolurus muricatus* that showed random distribution with respect to all environmental parameters tested except for mean minimum of the coldest month; this species was over-represented in the coldest part of the area (Table 3). The remaining six species in this category departed from randomness in respect to a number of parameters and distributional patterns may be influenced in more complex ways than for *A. muricatus* and *E. cunninghami*.

For the remaining species tests there were three or more environmental parameters for which tests could not be conducted and consequently optimal habitats are defined less completely. *Heteronotia binoei* and *Egernia striolata* are distributed randomly with respect to rock type, *Suta dwyeri* and *Pseudonaja textilis* to elevation, maximum temperatures and rock type, *Saproscincus rosei* to elevation and rock type, *Calyptotis scutirostrum* to elevation, *Ctenotus taeniolatus* to maximum temperatures, and *Morethia boulengeri* to maximum temperatures and rock type. Some of the species with a limited number of available tests were over-represented on some categories. *Heteronotia binoei* was over-represented at lower elevations and high maximum temperatures, *Bassiana platynota* at high elevations, *Ctenotus robustus* at low rainfall (see above), low elevation, and high maximum temperatures, *Ctenotus taeniolatus* to high elevations, *Egernia striolata* at low elevations, *Egernia whitii* at high elevations, *Eulamprus murrayi* at middle elevations, *Morethia boulengeri* at low elevations and low to medium rainfall, *Ramphotyphlops nigrescens* at high elevations and maximum temperatures in midrange, and *Austrelaps ramsayi* at high elevations (Table 3).

Various of the environmental attributes of the region are correlated with each other (e.g., temperature, elevation, and rainfall) and hence

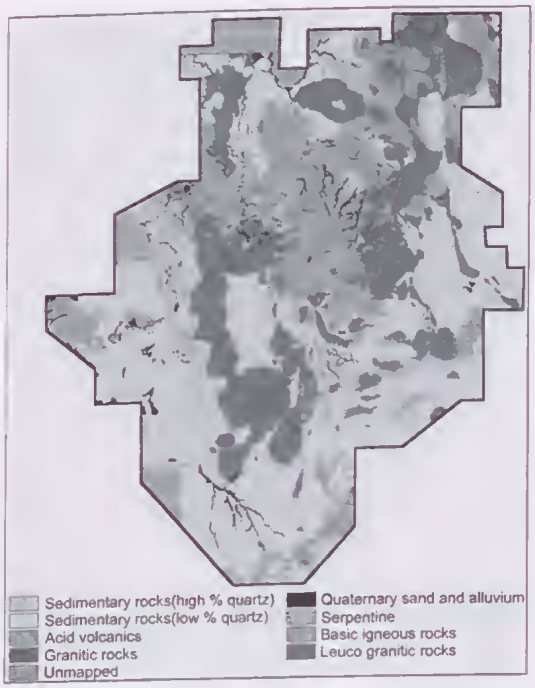

FIG. 115. Distribution of the various rock types in the study area. Derived from the Department of Minerals, geology 1:250k Mapping. Digitised and classified by NSW NPWS1993.

the precise factor or combination of factors that proximally affects distribution cannot be identified individually from the present data. However, assembling the suite of environmental levels at which a species shows over-representation, permits definition of its optimal habitat, and allows construction of testable hypotheses about proximal factors affecting distributions. Detection of features with which a species is randomly distributed is perhaps of even more importance as it identifies environmental parameters that are unlikely to be affecting a species distribution, at least within the range of values encountered in New England.

ACKNOWLEDGEMENTS

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ETNABATRACHUS MAXIMUS GEN. ET SP. NOV., A PLIO-PLEISTOCENE FROG FROM MOUNT ETNA, CENTRAL EASTERN QUEENSLAND

SCOTT A. HOCKNULL

Hocknull, S.A. 2003 06 30: *Etnabatrachus maximus* gen. et sp. nov., a Plio-Pleistocene frog from Mount Etna, central eastern Queensland. *Memoirs of the Queensland Museum* **49**(1): 327-330. Brisbane. ISSN 0079-8835.

Etnabatrachus maximus gen. et sp. nov. is the first record of fossil frogs from the Mount Etna region of central eastern Queensland. *E. maximus*' very large size, divided prominences and lateral mid-shaft ridge distinguish it from all other Australian genera. The associated fauna from the type locality indicates a Plio-Pleistocene rainforest environment, making *E. maximus* the largest known species of rainforest frog from Australia. ❐ *Etnabatrachus maximus, Plio-Pleistocene, Australia, Ilium, Cainozoic.*

Scott A. Hocknull, Queensland Museum, PO Box 3300, South Brisbane, 4101 (e-mail: scotth@qm.qld.gov.au); *20 May 2003.*

The first fossil frogs from Australia were described by Tyler in 1974 (Tyler, 1974). Since then, Tyler has published on taxa from the Eocene of southern Queensland through to the late Holocene deposits of South and Western Australia (Tyler, 1999). The dominating faunas exhibiting extinct taxa have been the Oligo-Miocene of Riversleigh Qld, Bullock Creek NT and Lake Palankarrina SA. The Pliocene to Holocene record is marked by the exclusively extant taxa illustrating an early establishment of the modern frog faunas.

Several new local faunas have been excavated from deposits from the Mount Etna Caves, Rockhampton, CE Queensland. These local faunas span the Pliocene to Holocene and preserve abundant frog remains, including species of *Lechriodus*, *Kyarannus*, *Litoria* and *Limnodynastes*. The age of the type locality for *Etnabatrachus maximus* gen. et sp. nov. is interpreted as late Pliocene to early Pleistocene based on taxa occurring across this boundary, including: *Petauroides* sp., close to *P. stirtoni* (Turnbull & Lundelius, 1970), *Pseudokoala* sp., close to *P. erlita* (Turnbull & Lundelius, 1970), *Palorchestes* sp., close to *P. parvus* (Tedford, 1994), *Perameles* sp., close to *P. bowensis* (Muirhead et al., 1997) and *Kurrabi* sp. (Flannery et al., 1992).

The type locality for *E. maximus* gen. et sp. nov. is interpreted as rainforest on the basis of sediments being at a time of major speleothem development, and taxa with distinct rainforest affinities, including: pseudocheirids – *Pseudochirulus mayeri*, *Pseudocheirops* spp. petaurids; *Dactylopsila* spp.; macropodids – *Dendrolagus* sp.; peramelimorphians – peroryctid spp.; murids – *Uromys* sp. and *Pogonomys* sp. nov. (H. Godthelp, pers.comm.); and anurans – *Lechriodus* sp. and *Kyarannus* sp.

Specimens described herein are deposited in the Queensland Museum fossil collection (QMF). Ilial terminology and nomenclature follow Tyler (1976) and taxonomy follows Cogger (2000).

SYSTEMATICS

Family ?HYLIDAE Gray, 1825

Etnabatrachus gen. nov.

TYPE SPECIES. *Etnabatrachus maximus* sp. nov. from the Plio-Pleistocene of Mount Etna and Limestone Ridge, localities QML 1385 (Type) and QML1284.

ETYMOLOGY. Etna- in reference to Mount Etna, type locality and -batrachus for frog.

DIAGNOSIS. Large, robust ilium. Ilial crest absent, dorsal acetabular expansion poorly developed, rising slightly above dorsal margin of ilial shaft. Preacetabular zone broad and divided laterally by a mid-shaft ridge. Ridge runs anterior to the acetabular rim, orientated anterodorsally approximately halfway along its length. Ridge terminates at ventral margin of shaft, at approximately anterior ¼ of ilium length. Dorsal prominence divided into an anterior and a posterior prominence, bisected by a shallow valley running from the anterio-medial side to the postero-lateral side. Anterior-most prominence laterally directed with elongate-ovoid protuberance in lateral profile. Anterior-most prominence placed well anterior of anterior acetabular rim. Posterior-most prominence smaller than anterior prominence with a more

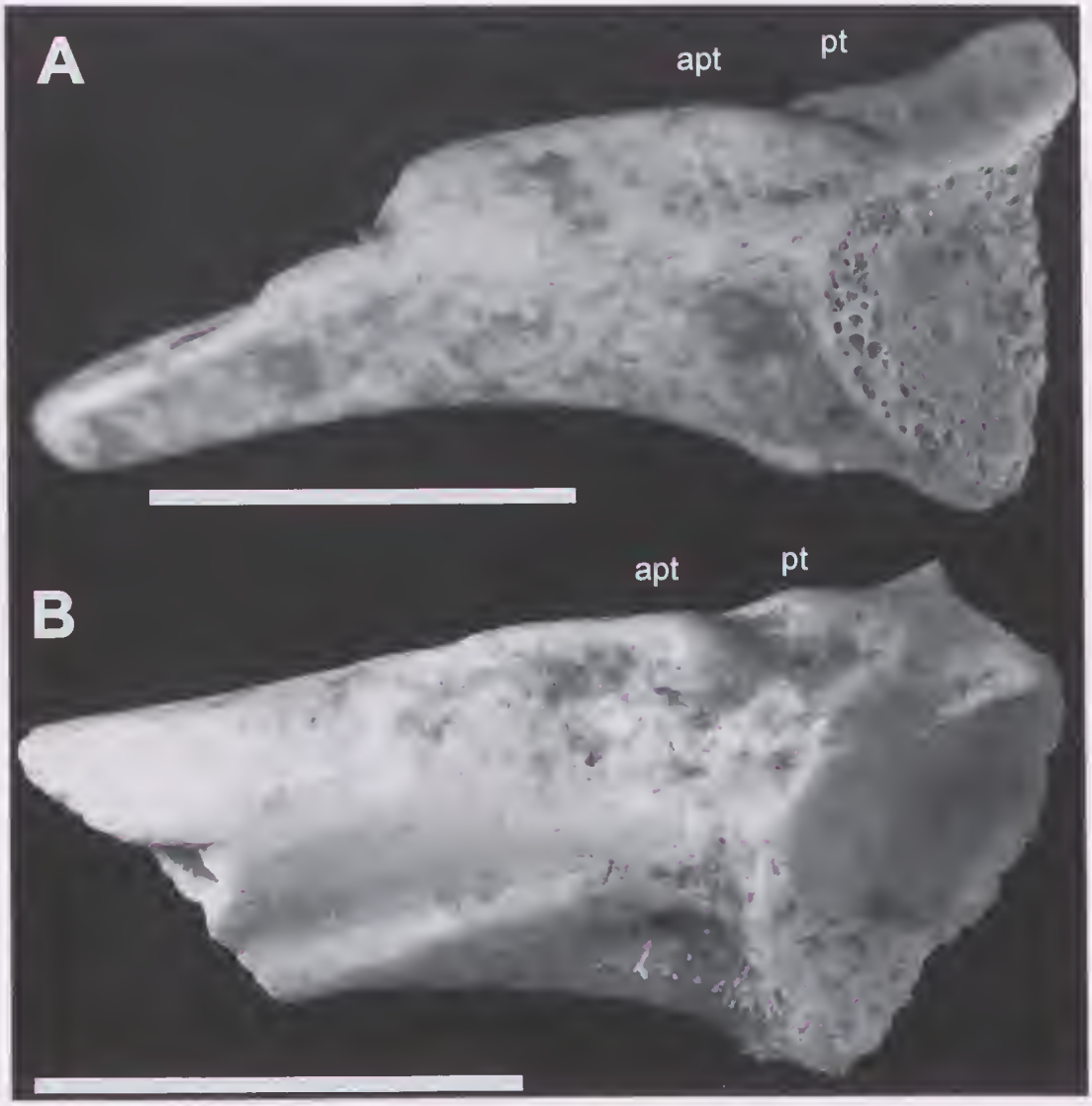

FIG. 1. *Etnabatrachus maximus* gen. et sp. nov. A, left ilium, Holotype QMF44207; B, left ilium, Paratype QMF44208. Scale = 5mm. apt, anterior-most protruberance; pt, proximal protruberance.

rounded proturberanee in lateral profile. Posterior-most prominence placed superiorly and central to acetabular fossa. Ilial shaft broad posteriorly, tapering sharply to anterior end.

DESCRIPTION. Holotype. QMF44207, is a large, robust left ilium preserving approximately half the posterior end, including a portion of the shaft, acetabulum, dorsal and ventral expansions and prominences. Dorsal acetabular expansion small and rounded superiorly, making a short ilial/ischial suture. Ventral acetabular expansion missing, broken on ventral margin, however, inferred as small with short ilial/pubic suture. Acetabular fossa large and well differentiated from ilial shaft. Acetabular rim narrow and produced laterally from the antero-posterior axis of the ilial shaft. Ilial shaft incomplete, broken approximately half way along its length, compressed medially and rounded laterally when viewed in cross-section. Preacetabular zone broad, broken postero-ventrally of acetabular

rim, superior to ventral acetabular expansion. Ridge runs antero-dorsally from ventral margin of acetabular rim, curves anteriorly half-way along its length positioned on the midline of the lateral side of the shaft. Curves antero-ventally along last 1/3 of its length, terminating on ventral margin of ilial shaft. Acetabular fossa eroded along posterior margin of fossa and anterior margin of acetabular rim. Dorsal prominence divided into two by a large groove running medio-laterally across ilial shaft. Groove terminates in a small basin, or insertion point, superior to dorsal acetabular rim. Anterior-most protuberance elongate-ovoid and laterally produced. Posterior-most protuberance ovoid in shape and antero-posterior in orientation, prominence terminating at the base of the dorsal acetabular expansion. Ilial shaft broad along its length, broken superiorly and perpendicular to the long axis of the ilium. Ilial length: 13.10+mm, dorsal acetabular expansion to ventral acetabular expansion height: 6.38+mm. Paratype QMF44208 is an incomplete left ilium, preserving the acetabulum, portions of both the dorsal and ventral acetabular expansions, divided prominences and preacetabular zone. Ilium large, robust along its length, broken approximately 1/3 its length. Ventral acetabular expansion unknown, inferred as diminutive in antero-posterior length and extending only slightly past ventral margin of acetabular rim. Acetabular fossa large with prominent narrow and high rim. Dorsal prominence divided into an anterior and a posterior prominence, bisected by a shallow valley running from the anterio-medial side to the postero-lateral side. Valley terminates as a small basin (muscular insertion point) positioned superior to the dorsal acetabular rim. Anterior-most prominence laterally directed with an elongate-ovoid protuberance in lateral profile. Anterior-most prominence placed well anterior of anterior acetabular rim. Posterior-most prominence smaller than Anterior prominence with a more rounded protuberance in lateral profile. Prominence less laterally positioned, terminating at the base of the dorsal acetabular expansion. Posterior-most prominence placed superiorly and central to acetabular fossa. Ilial shaft broad posteriorly, tapering sharply to anterior end. Ilial length: 10.20+mm, dorsal acetabular expansion to ventral acetabular expansion height: 5.14+mm.

REMARKS. The large size, divided prominence, lateral mid-shaft ridge and reduced dorsal acetabular expansion distinguish *Etnabatrachus* from all other known Australian genera. The rounded protuberance and lack of a dorsal crest ally this taxon closest to *Litoria* of Australia. However, specific placement in the Hylidae can only be tentative at this point. *Etnabatrachus* is considerably larger than the Oligo-Miocene *Litoria magna* Tyler, 1991, which Tyler (1991) considered to attain sizes of at least 120mm SVL. This puts *L. magna* in a size range greater than the largest extant *Litoria* (Cogger, 2000). It has been hard to estimate the SVL of *E. maximus* based on the lack of a complete ilium, however, the overall size of the ilium indicates a frog of considerable size, larger than 120mm SVL. The associated faunas recovered from the type locality indicate a palaeoenvironment of rainforest. Such a large species of frog in a rainforest deposit is not unusual as a number of species in present day rainforests attain large sizes (e.g. *Mixophyes* 115mm SVL and *Litoria* 120mm SVL).

Etnabatrachus maximus sp. nov.
(Fig. 1)

ETYMOLOGY. Latin, *maximus*, alluding to the large size of the species.

MATERIAL. HOLOTYPE: QMF44207, Paratype: QMF44208 from Plio–Pleistocene deposits, Mount Etna and Limestone Ridge (QML1284 & QML1385).

DIAGNOSIS. As for genus.

DESCRIPTION. As for genus.

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MACROINVERTEBRATE FAUNA OF AN IRON-RICH STREAM IN THE WET TROPICS OF AUSTRALIA: A COMPARATIVE ANALYSIS OF COMMUNITIES USING A RAPID BIOASSESSMENT PROTOCOL

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The present study examined an iron-rich stream in the Wet Tropics of Queensland, Australia, and used a Rapid Bioassessment Protocol to compare its macroinvertebrate fauna with that of (1) a nearby, undisturbed stream and (2) the second order stream formed from their junction. The undisturbed stream supported significantly greater levels of macroinvertebrate abundance and taxonomic richness than either the iron-rich or junction stream. The latter two streams did not differ significantly for either measure, suggesting that iron-layering effects maintain potency even at increased distances from the source (>1km). Percent Similarity (PS_{ij}) and Shannon-Weiner Diversity (H') indices were used to compare the streams' macroinvertebrate communities, while two biotic indices (SIGNAL) were employed to estimate water quality. The undisturbed stream exhibited greater invertebrate diversity and higher water quality relative to the other two streams. Species assemblage patterns were comparable to iron-rich stream studies from the temperate region: mayfly and caddisfly nymphs were almost completely absent from the sites of iron-deposition while they comprised the majority of the invertebrates in the undisturbed stream. The conservation issues and management implications surrounding the release of water from stratified dams and reservoirs are discussed. ❐ *Iron-rich, rapid bioassessment protocol, macroinvertebrate communities, Wet Tropics, dams.*

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Freshwater organisms confront a unique set of problems that are largely absent from terrestrial and marine environments. Bodies of freshwater, whether rivers, streams, ponds, or lakes, tend to be (1) small with respect to occupied volume and surface area, (2) patchy pattern across the landscape, and (3) sinks for pollutants and terrestrial run-off. Consequently, freshwater systems are highly sensitive to disturbance and pollution. The most frequent forms of aquatic pollution include thermal effluent, cultural eutrophication, acidification, build-up of sediments or suspended solids, and leakage of pesticides, petroleum products, and heavy metals (Hynes, 1960; Wiederholm, 1984; Kim & Chon, 2001; Mascaro et al., 2001). Construction of dams and other flow impediments may accelerate or intensify these processes. In addition to changing normal flow regimes, dams increase bank erosion, disturb flood cycles, impede migrations, displace native species, and alter pH, temperature, salinity, and natural chemistry of the waterway (Lake, 1967; Walker, 1981; Palmer & O'Keefe, 1990).

Anthropogenic sources of iron that may affect lotic systems include mining, logging, peat production, and agricultural run-off (Vuori, 1995). Less commonly, iron deposition may occur downstream from a stratified dam or reservoir. Thermal stratification in reservoirs creates an anoxic hypolimnion, and older dams with deep-release outlets may send ammonium-rich, oxygen-poor water downstream (Walker et al., 1978; Krenkel et al., 1979; Marcus, 1980). High quantities of iron can dissolve and concentrate within the anoxic water and, upon re-exposure to the oxygen-rich lotic environment, precipitate out to form a layer of ferrichydroxide. This deposition can seriously impact the resident flora and fauna, and iron deposition has been associated with diminished diversity and abundance for most recorded taxa (Hildrew & Townsend, 1976; Wellnitz et al., 1994; Wellnitz & Sheldon, 1995; Vuori, 1995). The occurrence of any anthropogenic impacts within the relatively pristine Wet Tropics is a major concern. The region is known as an area of significant ecological importance sustaining high

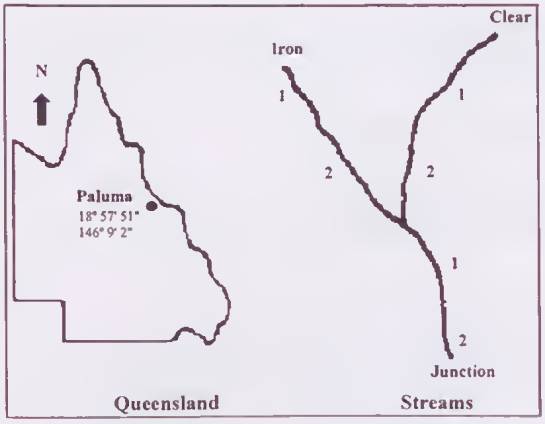

FIG. 1. Location of the study site. (Numbers indicate locations of sampling sites)

biodiversity, including many endemic and rare species. To illustrate this point, the area is known to contain 40% of Australia's fish species (Pusey & Kennard, 1996) and 25% of the terrestrial vertebrates (Williams et al., 1996) and 37% of the plants (Keto & Scott, 1986) are known to be regionally endemic.

We examined the macroinvertebrate fauna of a stream with heavy ferric-hydroxide deposition within the Wet Tropics of Australia. The stream flowed from a base-level leak in a peripheral saddle dam, wherein the iron is dissolved and concentrated. As a natural 'control', samples were also collected from a nearby stream which neither originated from the dam nor showed any signs of iron-deposition, but flowed over identical topography, soil type, and vegetation. The two streams eventually united into a second order stream, and the fauna below this junction was also sampled. Taxonomic richness, total abundance, and species composition were compared among the three areas. Two biotic indices of water quality were also calculated: the Stream Invertebrate Grade Number (SIGNAL) average family level and the weighted index (Chessman, 1995). The primary objective of this study was to use a rapid bioassessment protocol (RBP) to assess the effects of iron deposition on macroinvertebrate communities in an Australian tropical stream.

MATERIALS AND METHODS

Paluma is situated in the Wet Tropics of North Queensland (146°13'E, 19°S) and supports both rainforest and eucalypt forest areas. Study sites were located in an area of rainforest approximately 500m downstream from the Paluma dam (Fig. 1). At 890m above sea level, the dam itself has a maximum capacity of 9.5 billion litres and an average depth of approximately 15m. The 'iron stream' stems from a small leak at the base of a peripheral saddle dam (R. Pearson, pers. comm.) and is characterised by a distinctive, ochre deposit covering all rocks and leaf litter within the stream. An ostensibly undisturbed stream (henceforth referred to as the 'clear-stream') flowing from a nearby tributary was also sampled. The third sample site was located in the second order stream formed via the junction of the clear and iron streams.

In each stream, two sites were sampled: one at 50m and one at 100m from the point of junction. At each sample site, flow rate, canopy cover, mean width, mean depth, temperature, and substrate composition (percentages of cobble and leaf-litter) were estimated. For each sample, five similarly sized rocks were selected. Area was estimated by measuring the two longest axes of the rock; minimum and maximum recorded areas among the samples were 10,400mm^2 and 51,300mm^2, respectively. Each rock was lifted rapidly from the substrate and placed in a 400µm mesh dipnet, wherein the rock's surface was rigorously scraped free of all sediment and organisms. After a final visual inspection, the rock was replaced to the substrate while contents of the net were transferred to 70% ethanol and returned to the laboratory for sorting and identification. Macroinvertebrate specimens were identified to the level of family. A total of 30 rocks was examined.

Differences in macroinvertebrate abundance and taxonomic richness (family level) among the three streams were tested using Kruskal-Wallis tests followed by paired Mann-Whitney U-tests to isolate differences. To compare the structure and assemblage of macroinvertebrate communities, Shannon-Wiener Diversity (H') and Percent Similarity (PS_{ij}) indices (see equation 6.5 Jongman et al. 1995) were calculated. In accordance with Chessman's (1995) river rapid assessment protocol, the weighted index (SIGNAL-W) and the average family index (SIGNAL) were estimated. In these indices, specimens are keyed to family level and given an interim pollution sensitivity grade value (1-10). Chessman (1995) provided such grades for common families of Australian macroinvertebrates. For the weighted index, each family is also assigned an occurrence value (1-4), and the product of the occurrence value and the pollution sensitivity grade are summed across the sample. The

resulting SIGNAL values give an indication of water quality: clean water (value greater than 6), doubtful quality (values between 5 and 6), probable moderate pollution (values between 4 and 5), and probable severe pollution (values less than 4). The protocol was designed to yield rapid results and minimise time spent sampling and sorting. Chessman et al. (1997) has revised the grade numbers for a suite of macroinvertebrate families. We decided against using this updated SIGNAL index on the basis that the well represented families in our data set have not changed in grade number, and in addition some families do not have an updated grade number, hence allowing only a partial reanalysis.

RESULTS

The substratum of each stream was composed of rocks and leaf litter. The mean size of rocks (iron - 1101cm^2 ±46, junction - 1609cm^2 ±252 and clear - 1555cm^2 ±96) did not differ significantly between sites (ANOVA, d.f. = 2, 5, $F = 3.11$, $p = 0.19$). The abiotic characteristics of each stream are presented in Table 1.

The three streams differed significantly with respect to both macroinvertebrate abundance and taxonomic richness (Kruskal Wallis test, df=2, $p<0.0002$). The clear stream had significantly higher levels of both macroinvertebrate abundance and taxonomic richness than either the iron or junction stream (Mann-Whitney U test, $n_1 = n_2 = 10$, $p<0.005$; see Figs 2 and 3). No differences were noted for either measure between the iron and junction streams (Mann-Whitney U test, $n_1 = n_2 = 10$, $p>0.05$). Thus, at the scale of study, no increase in faunal abundance or taxonomic richness was noted with increasing distance from the anoxic source. Accordingly, visual observations showed no obvious decline in the layering of ferrichydroxide, even beyond the junction of the clear and iron streams. In both streams, several rocks were completely devoid of macroinvertebrates, in marked contrast to the densely populated rocks of the clear stream.

The similarity, diversity, and water quality analyses supported the trends noted for abundance and taxonomic richness. With respect to the collected families, percent similarity calculations (PS_{ij}) demonstrated a 40% similarity between the iron and junction communities, compared to 10.8% similarity between the junction and the clear streams and a 4.4% similarity between the clear and iron streams. For the Shannon-Weiner diversity index and the biotic indices of water quality, the clear stream had considerably higher values than either the junction stream or the iron stream (Table 2). The SIGNAL values classified the water of the clear stream as 'clean', while both the iron and junction streams fell into the 'moderately polluted' category (Chessman, 1995). Species assemblages from the different streams also differed substantially. The fauna list for the iron stream had no representatives of either Trichoptera or Ephemeroptera, which comprised approximately 50% and 25% of the clear stream fauna, respectively. The junction sample included one family in Trichoptera but lacked Ephemeroptera (Table 3).

DISCUSSION

Despite the temporal and spatial limitations inherent to the Rapid Bioassessment Protocol used in this study, it appears that iron deposition had substantial negative impacts on macroinvertebrate abundance and family-level richness. All indices had high values in the clear stream and low values in the iron and junction streams. This trend was most extreme for abundance, and clear stream samples supported more than ten times the number of macroinvertebrates found in either of the other streams. Another intriguing aspect of the results was the persistence of these effects with distance downstream. The fauna of the uppermost iron

TABLE 1. Abiotic descriptors for each stream. All values represent the mean for each stream.

	Iron Stream	Clear Stream	Junction Stream
% Leaf	37.5	16	22.5
% Cobble	45	60	60
% Canopy Cover	91	90	85
Width (m)	1.5	1.75	1.9
Depth (cm)	7.5	28.75	15
Flow (m/s)	0.24	0.03	0.13

TABLE 2. Results of the three indices calculated for each stream: Shannon-Weiner Diversity Index, SIGNAL (Stream Invertebrate Grade Number – Average Level per family), and SIGNAL-W (weighted by the occurrence of each family).

	Iron Stream	Clear Stream	Junction Stream
Shannon-Weiner	2.07	2.19	2.07
SIGNAL	4.14	6.44	4.71
SIGNAL-W	4.20	6.50	4.23

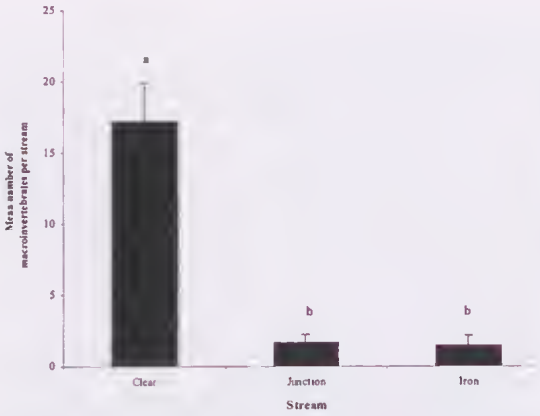

FIG. 2. Mean number of macroinvertebrates per stream. (Letters indicate significance groupings)

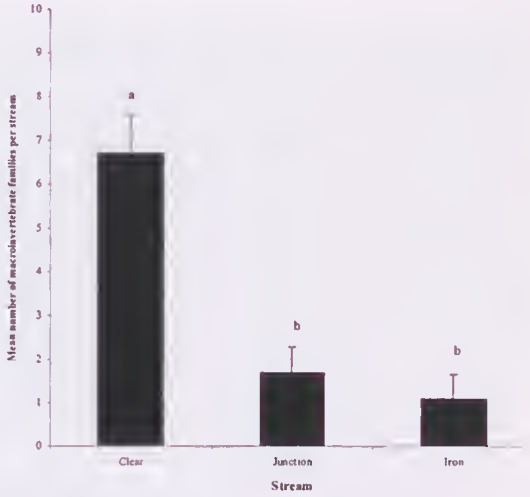

FIG. 3. Mean number of macroinvertebrate families per stream. (Letters indicate significance groupings)

sampling site and the lower junction site were equally depauperate, despite more than a kilometre separation, and supported similar macroinvertebrate communities. An exceptionally large distance may be necessary to observe any indications of 'recovery'. A study by Palmer & O'Keefe (1990) of the downstream effects of impoundments on water chemistry, has shown polluted streams may require up to 100km before regaining natural assemblages. In their study potential pollutants included agricultural runoff and urban effluents.

Iron-rich streams negatively impact macroinvertebrate abundance and diversity and alter the remaining species assemblage by affecting taxa differentially (Hynes, 1960). Previous studies of iron-rich streams correlate increases in iron deposition with the disappearance of most flora and fauna (Wellnitz et al., 1994). While still requiring experimental confirmation, the sediment layer created by the iron is the most likely causative agent. After leaving the reservoir, water from the iron stream is no longer anoxic, as the stream is shallow, fast flowing, and the iron has oxidised out of solution. The ochre layer of ferrichydroxide may negatively influence macroinvertebrates in at least five ways: by (1) reducing habitat complexity and available shelter, (2) interfering with holdfast mechanisms of certain species, (3) limiting periphytic algae colonisation, thus decreasing primary productivity and disturbing trophic relationships, (4) coating and blocking animals' respiratory surfaces, and (5) inhibiting proper ion exchange and osmoregulation (Hynes, 1960; Hildrew & Townsend, 1976; McKnight & Feder, 1984; Vuori, 1995). The possibility of toxic effects of iron traces in the water cannot be discounted, especially when levels are well above what is perceived as normal for rainforest streams in an undisturbed state. Unfortunately, few of these possibilities have been satisfactorily tested and their relative importance remains unknown. Presumably, the vertebrate fauna of streams is also affected by iron deposition, whether directly or indirectly. Within this study at least, *Myxophyes schevilli* tadpoles were found within the clear stream but not in either the iron or junction sites.

The impacts observed in the current RBP study parallel those of previous studies of iron-rich streams: a diminished fauna consisting of select macroinvertebrate orders. While the order Ephemeroptera is usually well represented in pristine, lotic streams, its absence from iron-rich streams is a universal trend in the literature. In general, mayfly nymphs are among the most sensitive aquatic insects to pollution (Wiederholm, 1984). Chessman (1995) gave Leptophlebiidae, three genera of which were represented in the clear stream but not in neither iron-rich stream, a pollution sensitivity grade of ten. Wellnitz et al., (1994) found three mayfly species showing increased mortality when caged within an area of high ferrichydroxide deposits. Similarly, Harding & Winterbourn (1995) noted poor mayfly representation in pastoral streams with high levels of iron relative to low-iron forest streams. The heightened sensitivity of mayflies is probably related to (1) the exposed nature of

Ephemeroptera gills and (2) their dietary dependence on periphytic algae (Roback, 1974).

The paucity of Trichoptera representatives in iron and junction streams also mirrors results from past studies in temperate areas (Wiederholm, 1984; Harding & Winterbourn, 1995). The two trichopteran families abundantly represented in the clear stream, Helicopsychidae and Leptoceridae, have sensitivity grades of ten and seven, respectively (Chessman, 1995). In contrast, the one caddisfly family found in the junction stream, Ecnomidae, is ranked with a grade of four (Chessman, 1995).

The report of an iron-rich stream within the relatively undisturbed Wet Tropics of north Queensland is potential cause for concern. The volume of water contributed by the iron and clear streams into the junction stream are comparable, but the biotic parameters of the second order stream are clearly more aligned with the iron stream. This finding was supported by all tested indices. In many respects, streams represent the veins of the surrounding landscape, upon which the health of the entire ecosystem may depend. Disturbances impacting waterways can create a type of 'ripple effect', influencing aquatic and terrestrial systems for a considerable distance. In this study, the ripple created by the anoxic stratification of Paluma dam maintained a nearly constant, negative amplitude for over a kilometre downstream. Mono- and biphasic aquatic vertebrates, not to mention terrestrial flora and fauna could suffer direct or indirect harm in areas close to iron-enriched streams. A number of stream breeding frogs have disappeared or are in decline in the Australian Wet Tropics, and further deleterious anthropogenic effects must be minimised (Williams & Hero, 1998).

The absence of multi-depth release valves in a dam or the presence of a fracture leak in a reservoir may seem of minor consequence, but the ecological reverberations can be intense. Iron-rich streams have an altered macroinvertebrate community structure and a shorter trophic chain than their unaffected counterparts (Hildrew et al., 1985). An iron sheath bacteria, *Leptothrix ochracea*, predominates in the presence of iron sediment but is absent in streams undisturbed by ferric hydroxide deposition. *Leptothrix ochracea* reduces naturally important populations of diatoms upon which many aquatic insects and other invertebrates graze (Sheldon & Skelly, 1990). Much of the natural periphyton is similarly lost following an influx of iron sediment. In England, several studies have focussed on iron streams due to the simplicity of their trophic structure (Hildrew et al., 1985; Lancaster & Robertson, 1995). Although little work has been done on iron-rich streams in tropical regions, the Rapid Bioassessment Protocol used in this study yielded the results one would expect with a more quantitative procedure, as illustrated by previous studies of temperate iron streams. Chessman et al. (1997) highlighted the uncertainty around the application of SIGNAL to other river systems, as the relationship between pollution-sensitivity grade numbers and types of polluting agents and disturbances remains unclear. We therefore acknowledge that the results of this study should be considered with appropriate caution until grade numbers developed for specific disturbances become available.

Results of this study are of importance as they demonstrate one of many impacts dam construction can have on local freshwater systems. This is especially disturbing if we consider the future plans for water resources in Queensland. In a recent release from the Department of Natural Resources (1997), 93 proposals for waterway development were recommended as having merit for inclusion in the Queensland Water Conservation Strategy. Considering that construction of dams typically alters the flow regime and water quality of local waterways, these proposals have the potential to increase environmental degradation of Queensland's aquatic habitats. This warrants an increased effort to monitor the impacts of dam construction on the health of aquatic ecosystems and employ such information in subsequent plans for further dam development. Without such research, Queensland, and possibly other regions of the world are in danger of jeopardising the future of their natural waterways.

Continued study of these Paluma streams will focus on three aspects: (1) persistence of the effects of iron deposition with increasing distance from the dam, (2) consequences of iron deposition on aquatic macroinvertebrates and streamside fauna, and (3) exact mechanisms through which deposited iron acts as such a potent disturbance.

ACKNOWLEDGEMENTS

We extend sincere appreciation to Gordon Kovacs for considerable advice and assistance in the keying of macroinvertebrate samples, and to Richard Pearson, for initially directing us toward the study of iron-rich streams and supplying

TABLE 3. Taxonomic list and relative abundance of macroinvertebrates in the Clear, Iron and Junction streams at Paluma.

Order	Suborder	Family	Genus	No. Individuals	% of Total
Iron					
Arachnida		Porohalacaridae		3	0.20
Coleoptera		Elmidae		1	0.07
Diptera		Tanyderidae		2	0.13
Diptera		Thaumaleidae		1	0.07
Diptera		Unidentified		1	0.07
Gastropoda		Planorbidae	*Segnitila*	1	0.07
Hemiptera		Veliidae	*Rhagovelia*	4	0.27
Odonata	Anisoptera	Unidentified		1	0.07
Pleeoptera		Gripopterygidae		1	0.07
Clear					
Diptera		Ceraptopogonidae		2	0.01
Diptera		Chironomidae		19	0.11
Diptera		Dixidae		1	0.01
Diptera		Empididae		1	0.01
Diptera		Psychodidae		2	0.01
Ephemeroptera		Caenidae		7	0.04
Ephemeroptera		Leptophlebiidae	*Atalophlebia*	13	0.08
Ephemeroptera		Leptophlebiidae	*Austrophlebiodes*	7	0.04
Ephemeroptera		Leptophlebiidae	*Ulmerophlebia*	8	0.05
Ephemeroptera		Leptophlebiidae	*Unidentified*	8	0.05
Ephemeroptera		Unidentified		2	0.01
Hemiptera		Veliidae	*Rhagovelia*	2	0.01
Odonata	Anisoptera	Corduliidae		2	0.01
Odonata	Anisoptera	Unidentified		1	0.01
Odonata	Zygoptera	Chlorolestidae		2	0.01
Odonata	Zygoptera	Lestoideidae		2	0.01
Plecoptera		Eustheniidae		1	0.01
Triehoptera		Calamoceratidae		5	0.03
Trichoptera		Ecnomidae		4	0.02
Trichoptera		Helieopsychidae		37	0.22
Trichoptera		Leptoceridae		41	0.24
Trichoptera		Philorheithridae		1	0.01
Trichoptera		Polyeentropodidae		1	0.01
Junction					
Arachnida		Porohalacaridae		3	0.18
Diptera		Chironomidae		4	0.24
Diptera		Empididae		1	0.06
Diptera		Tipulidae		1	0.06
Diptera		Unidentified		1	0.06
Hemiptera		Veliidae	*Rhagovelia*	1	0.06
Odonata	Anisoptera	Corduliidae		2	0.12
Odonata	Zygoptera	Amphipterygidae		2	0.12
Trichoptera		Ecnomidae		2	0.12

guidance in both experimental design and data analysis for the project. Richard Rowe provided critical information regarding the life histories of some of the collected taxa, for which we are likewise grateful. We are indebted to Zury Soto, Sapna Khandwala, and Eric Beerbohm for editing the manuscript. Marg Criniti deserves special mention for furnishing the necessary supplies and storage space during the course of the study. Logistical support for this project was provided by the Australian Centre for Tropical Freshwater Research.

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CASE HISTORIES OF ATTACKS BY THE SOUTHERN CASSOWARY IN QUEENSLAND

CHRISTOPHER P. KOFRON

Kofron, C.P. 2003 06 30: Case histories of attacks by the Southern Cassowary in Queensland. *Memoirs of the Queensland Museum* **49**(1): 339-342. Brisbane. ISSN 0079-8835.

The Southern Cassowary is Australia's largest bird and is capable of causing serious injuries to humans. The incidence of cassowary attacks in Australia was reviewed recently by Kofron (1999). The eight recorded incidents in which humans were seriously injured by Southern Cassowaries are examined, and also other related incidents of special interest. The eight seriously-injured victims suffered puncture wounds, lacerations, cuts, and/or broken bone, one of them subsequently dying. Five of the eight attacks were by cassowaries that had been fed previously by people, and in the single fatal cassowary attack recorded in Australia the victim was trying to kill the cassowary. Also, four of the eight seriously-injured victims were crouching or lying on the ground. Consequently a person encountering a cassowary should not crouch down, which puts a person's head and vital organs in closer striking range of the cassowary's foot. Rather, a person should remain standing and move behind a tree, or quickly leave the area but without turning one's back. Children should be supervised and kept at safe distances from cassowaries, especially cassowaries habituated to people. People should be aware that cassowaries can be dangerous in certain situations. ❐ *Southern Cassowary, Casuarius casuarius johnsonii, Queensland, attacks.*

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The Southern Cassowary (*Casuarius casuarius johnsonii*, family Casuariidae) is endemic to the tropical rainforests of northeastern Queensland. This species is Australia's largest bird and holds a reputation for being dangerous. Cassowaries and Ostriches are the only birds worldwide that have caused human deaths by physical attack. Incidents occur every year in Queensland, most at Mission Beach (110km SE Cairns) but previously also at Lake Barrine (39km SW Cairns) and Mount Whitfield in Cairns.

The incidence of cassowary attacks in Queensland was reviewed recently by Kofron (1999), who reported on data for 221 attacks against humans and domestic animals. One hundred fifty attacks were against humans, 75% of these by cassowaries fed previously by people. The feeding of cassowaries appears to change their natural behaviour, making them bold and aggressive. Victims were chased or charged in 71% of the incidents, and kicked in 15%. Less frequent actions included pushing, pecking, jumping on, butting with the head and snatching food. The cassowaries appeared to be expecting or soliciting food from humans (73% of the incidents); defending food (5%); and defending themselves (15%) or their chicks or eggs (7%). The purpose of the present paper is to examine the eight recorded incidents in which humans were seriously injured, and also other incidents of special interest, with a view to identifying the hazards and minimising the risks in human-cassowary interactions.

METHODS

I questioned and interviewed persons likely to have knowledge of or experiences with cassowaries (e.g. rangers, field workers, farmers, veterinarians, wildlife carers). In addition, I examined official records of the Queensland Parks and Wildlife Service and the Queensland Police Service, and also newspaper reports. All information presented here is based on first person and eyewitness accounts, except one incident known only from two newspaper reports. An injury was considered serious if it required treatment by professional medical personnel, and these included deep puncture wounds, lacerations and cuts needing stitches, and fractured bone. Where possible, I spoke with the victims and the medical personnel.

RESULTS

ATTACKS TO HUMANS RESULTING IN SERIOUS INJURIES. Eight attacks by wild cassowaries resulted in serious injuries to humans in the following parts of the body: throat; buttocks; chest; scrotum, chest and forearm;

upper arm; thigh and forehead; lower leg; and middle finger. One victim subsequently died. The cassowaries kicked or jumped on the victims, four which were crouching or lying on the ground (one tripped, one knocked to the ground). In three of these attacks the cassowaries appeared to be soliciting food and in three attacks acting in self-defence; but two of the attacks remain unexplained.

Boy killed near Mossman, puncture wound in neck, 1926. On 6 April 1926, two dogs and two boys (Phillip McLean 16 years, Granville McLean 13) attacked a cassowary at their paddock near Mossman (67km NW Cairns), striking the bird and trying to kill it. The cassowary kicked one dog and the younger boy, who stumbled away, but the other dog and boy pressed on with their attack. When the cassowary advanced on the older boy, he ran but tripped, falling to the ground face upwards. The cassowary jumped on him, its spike-like claw penetrating the boy's neck (puncture wound $1^{1}/_{4}$ cm diameter) and severing a blood vessel. The boy got up and ran, but soon collapsed and died from loss of blood.

Woman kicked on Mount Whitfield track, wound in buttock, 1988. Two newspaper articles published on 13 March 1988 (Anonymous, 1988a) and 15 March 1988 (Anonymous, 1988b) reported that a woman was attacked by a cassowary at Mount Whitfield, and the wound in her buttock required stitches. Although one article claimed that the woman was bitten by the cassowary, it is likely that she was kicked. The recent cassowaries at Mount Whitfield were fed by people.

Man kicked at Julatten, puncture wound in chest, 1990. On 2 October 1990, Barry and Jenny Tuite walked along Clacherty Road in Julatten (57km NW Cairns), bound by rainforest, orchards, paddocks and houses. They did not notice the cassowary at the rainforest edge until only several metres distant from it. They walked away, but the bird followed for about 50m. Suddenly the cassowary charged, leapt and kicked the man in his chest (puncture wound 12cm deep), knocking him to the ground. As he lay unconscious in a drain, the cassowary attempted to kick him again. The woman shouted; the cassowary advanced towards her, and she ran up an embankment. The injured man regained consciousness and also climbed the embankment. The woman ran to a nearby farmhouse for help, with assistance arriving as the cassowary again was confronting the injured man. The bird moved away only a short distance as Mr Tuite was assisted into a motor vehicle. When the cassowary approached again, the farmer shot and killed it.

The reason for the attack is unknown. No dogs or cassowary chicks were involved, and residents denied feeding the female cassowary, although one person alleged the contrary. One day prior to the attack, two people on horses were chased by a cassowary along Clacherty Road; and one or two weeks prior in Julatten, cows were chased by a cassowary.

Man kicked at Cape Tribulation, lacerations in forearm, chest and scrotum, 1991. On 11 September 1991 at 02:00, Bodo Wintergerst walked out of his caravan at Bailey's Creek (88km NW Cairns) to toilet in the rainforest. He claims that a cassowary kicked him while squatting, lacerating his forearm, chest and groin. The linear cuts required 9 stitches: right forearm 2, right upper chest 3 and left side of scrotum 4. The alleged attack cannot be explained.

Woman kicked on Mount Whitfield track, puncture wound in upper arm, 1994. On 20 December 1994, Joanne Edwards was walking the Blue Arrow Track at Mount Whitfield when a cassowary approached her from behind. The bird stopped 5m away and preened its chest feathers. The woman stepped backwards, and the cassowary advanced. The woman crouched down and covered her head with an arm. The bird kicked Ms Edwards in the arm, knocking her to the ground, and then kicked her several times more in the arm and stomach. Eventually the cassowary walked away. The woman received a puncture wound in the upper arm that required 10 stitches.

Woman kicked on Mount Whitfield track, puncture wound in thigh, lacerations in forehead, 1996. On 30 March 1996, Jill Turner was walking the Blue Arrow Track at Mount Whitfield when a cassowary approached her from behind. The woman continued walking, and the bird followed. Eventually she stepped off the track to allow the cassowary to pass, but it stopped at 1m distance. The cassowary briefly looked at the woman and then kicked Ms Turner in the thigh, knocking her to the ground. The cassowary quickly kicked her again in the forehead and twice in the back. The cassowary sat down next to her (2m distance) for 10 minutes; then got up, walked 4m and sat down for 30 minutes; and then got up and walked away down the track. The woman received puncture wounds in her thigh and lacerations in her forehead that required two and nine stitches, respectively.

Man kicked at Stratford, Mount Whitfield, fractured lower leg, 1996. On 2 November 1996, James Barry saw two dogs attacking a cassowary on the residential lot adjacent to his, one biting the bird's neck and the other its leg. As he pulled one dog away, the cassowary kicked Mr Barry in the shin, causing a simple fracture of his lower leg. The cassowary was obviously acting in self defence (it subsequently died), not realising that Mr Barry was attempting to help it. This bird had a history of being fed by people.

Man kicked at Etty Bay, cut on finger, 1999. On 25 December 1999, George Newport saw two children on bicycles confronted by a cassowary at his caravan park. To assist the children and shoo away the bird, Mr Newport approached the cassowary with an umbrella, holding it with two hands in front while opening and closing several times, which had proven effective on previous occasions. As Mr Newport neared the cassowary, the bird jumped up and kicked the umbrella, also striking the man's hand. The cassowary then walked away. Mr Newport suffered a cut to his middle finger that required five stitches. This bird had a history of being fed by people.

SOME OTHER ATTACKS TO HUMANS. *Man kicked at Mission Beach, 1986.* In one incident in 1986 at Mission Beach, a tourist was viewing a cassowary. The bird approached the person to within 1m, apparently expecting to be fed. Instead of offering food, the tourist squatted down to photograph the cassowary. Suddenly the bird kicked the person in the stomach, knocking him to the ground.

Cassowary jumped up and down on man at Aeroglen, Mount Whitfield, 1991. In November 1991, a friend was visiting Joseph Collins at his residence on Mount Whitfield. The fig tree in his yard was frequented by a cassowary, and the bird was feeding during the visit. The two men viewed the cassowary at close quarters, picked up figs and fed it by hand. The visitor moved backwards to photograph the bird, lost balance and fell to the ground. The cassowary quickly jumped onto the prone man's back, and then jumped up and down on him about 10 times. This action of the cassowary appears to have been in defence of its food and feeding area.

Man head-butted on Mount Whitfield track, 1995. On 29 October 1995, three hikers on the Blue Arrow Track at Mount Whitfield encountered a cassowary preening itself. The hikers went off the trail intending to circumvent the bird, but upon their emerging back onto the track the cassowary was waiting for them only 2m away. The cassowary lowered its head, charged and butted Clive Skarott in the back. While falling he grabbed a narrow tree trunk, the momentum spinning him around the tree and back again to face the cassowary. The man quickly retrieved an apple from his pocket and offered it to the cassowary, which the bird ate from hand. The man offered a second apple, which was also eaten. A third apple was offered, but then rolled down the slope, which the cassowary pursued.

Boy pecked on testicles at Aeroglen, Mount Whitfield, 1995. In another incident in October 1995 at Mount Whitfield, the son of Ann Keating went outdoors to play. A cassowary was feeding at a fig tree in their garden, which the bird frequented regularly. The little boy (age four) climbed onto a fence post about $1\frac{1}{4}$ m height, and the cassowary walked to him. The cassowary pecked the boy, striking him on the testicles. I attribute this action of the cassowary to defence of its food and feeding area.

SERIOUS INJURIES TO DOMESTIC ANIMALS. Although injuries to dogs are included here, the dogs were usually the aggressors and were threatening the cassowaries. In 29 of 35 recorded incidents, the cassowaries were acting in self defense because they were being attacked by dogs. Conversely and most importantly, many cassowaries have suffered injuries and even death because of dogs, which will be the subject of a separate paper.

Dog killed at the Tully River, puncture wound in chest, 1976. One day in 1976 Les Henry drove with his dog to the Tully River (124km S Cairns). Upon getting out of the motor vehicle, the dog sighted a cassowary, then barked and ran to it. As the dog drew near, the cassowary took several steps toward the dog, and then kicked the dog in its chest making a deep puncture wound. The dog died shortly after.

Dog killed at Bramston Beach, ruptured intestine, 1995. In one incident in 1995 at Bramston Beach (54km SE Cairns), a dog was chasing a cassowary. The cassowary turned to confront the dog, and then kicked the dog in its belly. Although there was no puncture wound, there was massive bruising. The dog subsequently died, apparently from a ruptured intestine.

20 dogs kicked, puncture wounds, lacerations and cuts, 1976-1996. Six veterinarians in Innisfail (72km SE Cairns), Mission Beach and Tully treated 20 other dogs with puncture wounds,

lacerations and cuts caused by cassowaries. All injuries were in the torso (10 in the chest), and each dog required 2-20 stitches.

Horse kicked at South Mission Beach, laceration in buttock, 1987. Rangers Brent Vincent and Karl Siener conducted a situation assessment of a race horse that had been kicked by a cassowary at South Mission Beach in 1987. This particular cassowary was being fed fruit (pineapples, bananas, apples) on the adjacent farm as part of the wildlife rescue effort following Cyclone Winifred. While the horse was feeding at its own trough, a cassowary kicked the horse twice, in its ribs and buttock. The horse suffered a deep laceration about 18cm long in the upper thigh that required stitches.

DISCUSSION

Eight attacks against humans resulted in serious injuries and subsequently one death, caused by cassowaries kicking or jumping on victims. Five of these eight attacks were by cassowaries that had been fed previously by people. In the single fatal cassowary attack recorded in Australia, the victim was trying to kill the cassowary. In consideration of all the data, I conclude that feeding cassowaries changes their natural behaviour, making them bold and often aggressive towards humans. Cassowaries that are fed become habituated to humans, subsequently recognising humans as a source of food. For example, of the 90 cassowary attacks recorded at Mount Whitfield (Kofron, 1999), I suspect that no more than four cassowaries were involved, and some of the serious injuries were probably by the same cassowary.

Four of the eight human victims that suffered serious injuries were crouching or lying on the ground, and 22 dogs were seriously injured when kicked. Consequently a person encountering a cassowary should not crouch down, which puts a person's head and vital organs in closer striking range to the cassowary's foot. Rather, a person should remain standing and move behind a tree, or quickly leave the area but without turning one's back. Children should be supervised and kept at safe distances from cassowaries, especially cassowaries that are habituated to people.

Much of the Southern Cassowary's tropical rainforest habitat is now highly fragmented, and human-cassowary interactions will continue to occur, especially in the Mission Beach/Tully/Innisfail area. People must be aware that cassowaries are capable of causing serious injuries, and they can be dangerous in certain situations.

The Southern Cassowary is an endangered species, and one of the threatening factors is dogs. Owners should not allow dogs to roam at large because of their impact on native Australian wildlife, including cassowaries.

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The views expressed in this paper are those of the author and do not necessarily reflect those of the Queensland Parks and Wildlife Service or those of the Queensland Government.

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TWO NEW SPECIES AND OTHER RECORDS OF SEA SPIDERS (PYCNOGONIDA: ARTHROPODA) FROM TROPICAL NORTH QUEENSLAND

A.C. LEE AND C.P. ARANGO

Lee, A.C. & Arango, C.P. 2003 06 30: Two new species and other records of sea spiders (Pycnogonida: Arthropoda) from tropical North Queensland. *Memoirs of the Queensland Museum* **49**(1): 343-348. Brisbane. ISSN 0079-8835.

Five species of sea spiders found among the green intertidal algae *Cladophora prolifera* (Roth) and the coastal soft bottoms of Cleveland Bay off Townsville, are reported. Two new species are described; *Ammothella fistella* sp. nov., a closely related species of the appendiculata-group, and *Callipallene catulus* sp. nov., an extremely small species differentiated by its size and general body shape. Three species of *Anoplodactylus* are also recorded, *A. glandulifer* a widely distributed species, *A. cribellatus*, a recent synonym of the Australian *A. simplex*, and *A. tubiferus*, a long-known species from the West-Pacific. The finding of undescribed species in the alga *C. prolifera* encourages the interest on intertidal habitats that might serve as shelter for possibly many others small to tiny pycnogonids. ❐ Pycnogonida, *Ammothella, Callipallene, tropical sea spiders.*

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This is a report of a small collection of pycnogonids from Townsville, in tropical North Queensland. It comprises three named species plus the description of two new species, adding them to the list of 34 species known from Queensland. Studies on pycnogonid fauna from the North Queensland region are few and sporadic. Reports on the fauna have rarely been a result of active search. Instead, many of the specimens found were primarily taken from dredge and grab, or trawled samples, usually with expeditions (Clark, 1963; Child, 1975). In the last 20 years the only reports on sea spiders from Australia are those by Staples (1982), on pycnogonids from the vicinity of Gladstone, Child (1990) on the 15 species reported from the Great Barrier Reef, and Arango (2003) also recording new species from North Queensland. The present note constitutes a complement to that larger report on pycnogonids from tropical Queensland and nearby areas (Arango, 2003). The discovery of two new species of pycnogonids in a very small collection of green algae is an indication that the pycnogonid fauna of this region is much more diverse than previously thought, especially of very small forms of pycnogonids that predominate in a diversity of shallow water habitats.

Rowes Bay (19°15'S, 146°47'E) and Cleveland Bay constitute the area of collection of the present report. The intertidal habitat of Rowes Bay, composed of small boulders and a mixture of muddy and sandy sediment and a large diversity of benthic organisms and various algal species, was explored by the authors in different times of the year in 1998 and 1999. Aside from this, dredge and grab collections of the soft benthos of Cleveland Bay were obtained. *Anoplodactylus* species were dominant, followed by *Ammothella* and *Callipallene*. *Anoplodactylus glandulifer* Stock, 1954, *Ammothella fistella* sp. nov. and *Callipallene catulus* sp. nov. were collected among the algae *Cladophora prolifera* (Roth); while *A. cribellatus* Calman, 1923 (syn. *A. simplex* Clark, 1963) and *A. tubiferus* Haswell, 1884 were collected by dredge and grab in the muddy bottoms of Cleveland Bay.

Although the area of North Queensland might be a well-studied region regarding the pycnogonid fauna compared to other Australian regions, the two previously undescribed species in such a small collection suggests that little collecting has been done, especially of very small forms of sea spiders that predominate in a diversity of shallow water habitats.

SYSTEMATICS

AMMOTHEIDAE Dorhn 1881

Ammothella fistella sp. nov.
(Fig. 1)

ETYMOLOGY. Latin, *fistella*, diminutive of fistula, meaning a pipe, tube or ulcer; suggested by Dr C. Allan Child. It refers to the various tubular spines on the lateral processes and appendages.

MATERIAL. Townsville, Rowes Bay, intertidal rocky, found on the green alga, *Cladophora prolifera* (Roth) in 0.5m, April-November 1998,1♂, holotype, (QM S105865), coll. Lee; April-November 1998. Paratypes, 1♂ with eggs, 3♀, 16 juv. paratypes (QMS105866), 4♂, 2♀, 1 juv., coll. Lee; April-Nov1998, 1♂ with eggs, 1♀, 1 juv., (QMS105866), coll. Arango; Apr. 1999, 1♂, 4♀, 1 juv. (QMS105867), coll. Arango.

DISTRIBUTION. Known only from Rowes Bay, Townsville, Qld, 0.5m tidal height.

DESCRIPTION. Relatively small, leg span of 6.84mm. Trunk robust, spinose, with numerous short tubular and long pointed spines. Lateral processes separated by half their diameter or less, ornamented with three similar dorso-distal tubular spines, last pair of lateral processes with one single tubular spine: tubular spines all taller than their diameters. Abdomen long, curving posteriorly, bending horizontally at midpoint, ornamented with four short and two long tubular spines and four short pointed lateral spines. Ocular tubercle of moderate length, pointed anteriorly, 2.5 × longer than distal diameter. Eyes large, darkly pigmented, located distally. Neck robust, expanded distally, without ornamentation. Proboscis typical, with swollen medial section, with proximal and distal constrictions. Chelifores slender, lightly spinose, with double jointed-scape, first segment slightly shorter than second, ornamented with one dorso-median tubular spine, one dorsodistal, two latero-distal tubular spines and two pointed spines of similar length. Second segment ornamented with 5-8 dorsal and lateral tubular spines and 3-4 dorsal pointed spines. Chelae reduced, distal end resembling club. Palps long, slender, without tubular spines, consisting of 9 segments, with ventro-distal spines slightly longer than their segment diameters. Ovigers typical, strigilis segments denticulated, with many lateral denticles. Two large and long setae located laterally on seventh segment. Legs slender, spinose, with large number of short and long pointed spines and numerous tubular spines; first coxae similar to anterior lateral process, with 3-4 dorsodistal tubular spines and 4-5 lateral and ventral pointed spines; second coxa has 3 dorso-median short tubular spines and very small ventro-distal spines; third coxae with 3 short ventro-distal spine; femur slightly shorter than subequal tibia; all leg segments armed with randomly located tubular spines, longer pointed spines dorsally and distally and short ventral spines. Cement gland dorso-distally, tube of slightly longer than segment diameter, carried horizontally; tarsus short, propodus well curved, with 4 heel spines and 6-7 sole spines, several dorsal setae located randomly; claws half as long as propodus, auxiliary claws long, roughly 0.8 claw length.

Female. Easily identified, with fewer tubular spines on legs and lack of conspicuous femoral cement gland. Females slightly larger, however, possess smaller oviger than males. Juveniles have fully functional chela, crossing at tips, with simple teeth; chelifores slender and spinose. Juveniles are also easily identifiable with oviger buds.

Measurements. Holotype (in mm). Trunk length (chelifore insertion to tip of fourth lateral processes), 0.77; trunk width (across second lateral processes) 0.67; proboscis length 0.6; abdomen length 0.52; third leg, coxa I 0.2; coxa II 0.3; coxa III 0.23; femur 0.57; tibia I 0.6; tibia II 0.58; tarsus 0.1; propodus 0.38; claw 0.16.

REMARKS. This new species is closely related to two other species known from the Pacific: *A. tippula* Child, 1983 and *A. pacifica* Hilton,1942. The primary difference between this new species and *A. tippula* is seen in the tubular spines on the lateral processes. *A. tippula* has low dorso-distal knobs and short lateral spines on lateral processes, lacking tubular spines on these regions. *A. fistella* has three articulated short tubular spines on the dorsodistal edge of the first three pairs of lateral processes and a single tubular spine on the last lateral process pair. *A. pacifica*, on the other hand, lacks any form of tubular spines on its lateral processes but possesses short postero-lateral spines bearing lateral setules ('feathered spines') on the two anterior pairs and no spines on the two posterior pairs. *A. pacifica also* lacks spines of any form on the antero-lateral corners of its trunk, while the same corners of *A. tippula* and *A. fistella* each have a short tubular, inarticulate spine.

The appendages of *A. tippula* and *A. pacifica* have tubular spines that are uniformly longer than those found on *A. fistella*. The first segment

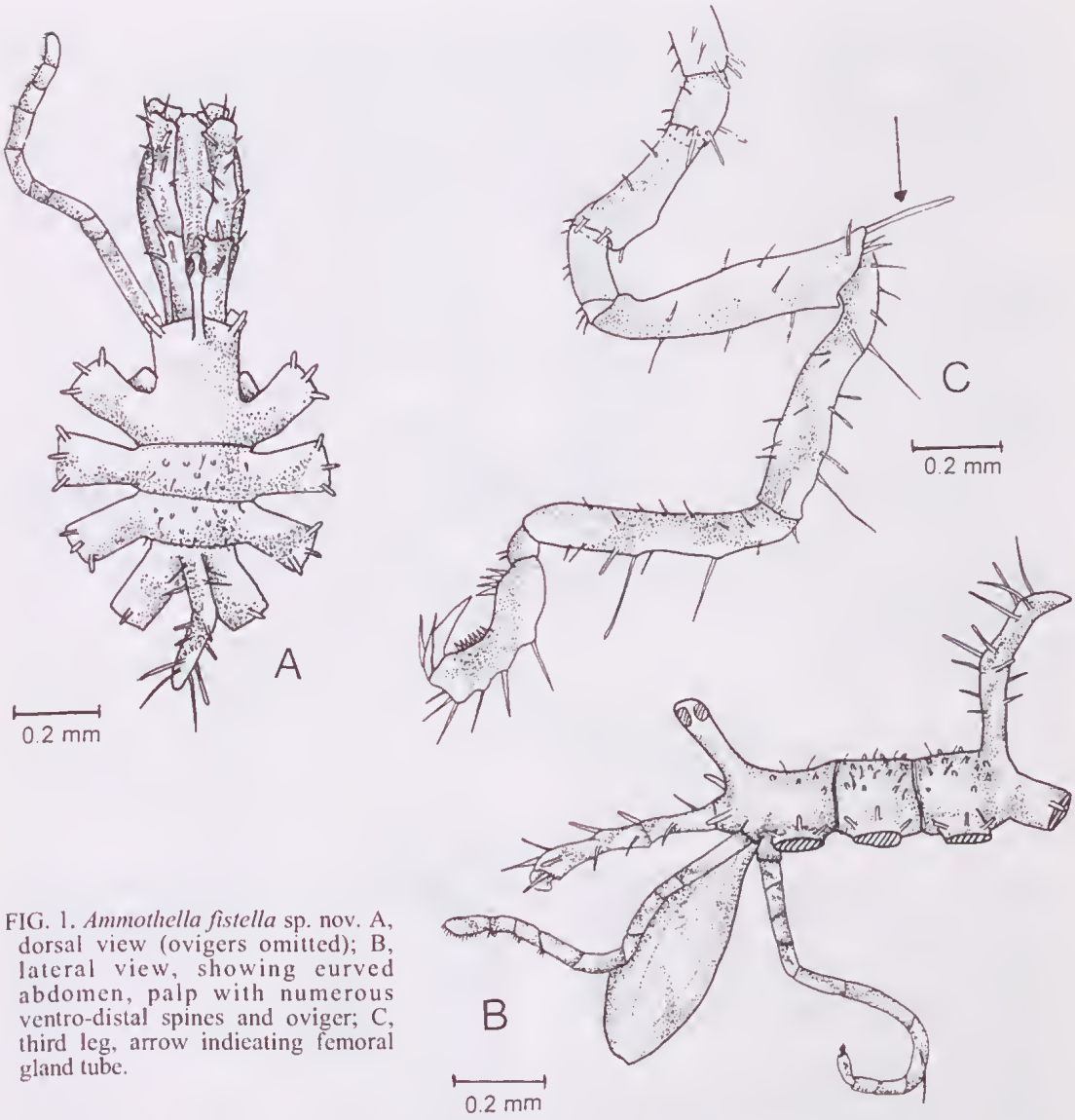

FIG. 1. *Ammothella fistella* sp. nov. A, dorsal view (ovigers omitted); B, lateral view, showing curved abdomen, palp with numerous ventro-distal spines and oviger; C, third leg, arrow indicating femoral gland tube.

on the chelifore of these two species has 1 dorsal tubular spine while the same segment on *A. fistella* has 4. The second scape segment of *A. fistella* has numerous short tubular spines, more than any of the other two related species.

Ammothella fistella is less closely related to its nearest geographic neighbour, *A. prolixa* Child, 1990, collected from Orpheus Island, north of Townsville, although they appear slightly similar. *Ammothella prolixa* has a more stretched or attenuated habitus with more slender appendages than the other species discussed. It has fewer tubular spines and lacks spines or setae on its lateral processes.

CALLIPALLENIDAE Hilton, 1942

Callipallene catulus sp. nov.

(Fig. 2)

ETYMOLOGY. Latin, *catulus*, young of an animal; suggested by Dr Allan Child. It refers to the inflated, juvenile appearance of the trunk.

MATERIAL. Townsville, Rowes Bay, intertidal rocky bund, on the green alga, *Cladophora prolifera* (Roth) in 0.5m, 1998, 1♂, holotype, (QMS105868) April-November 1998, coll. Lee; Paratypes, 1♂ with eggs, 3♀

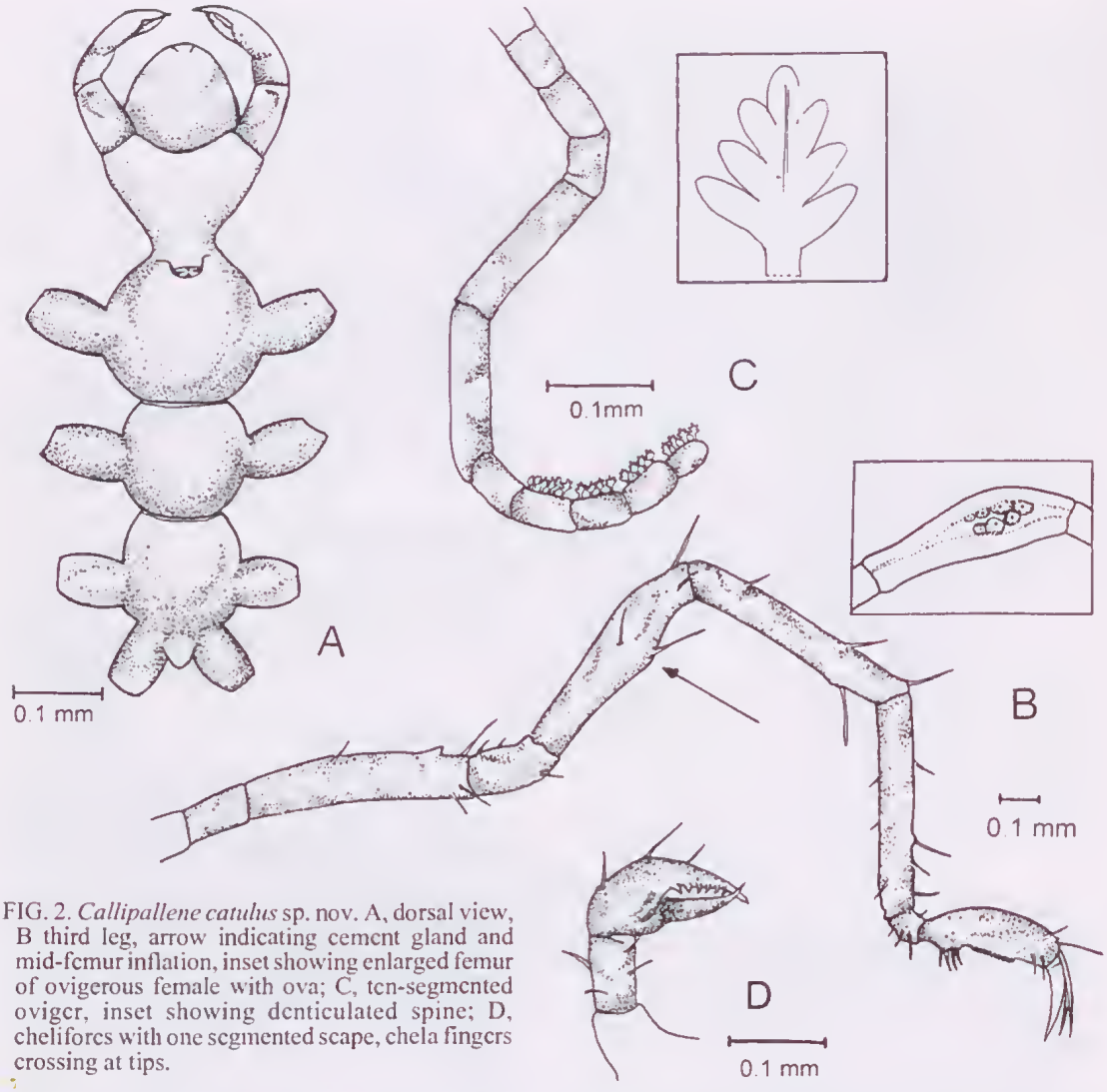

FIG. 2. *Callipallene catulus* sp. nov. A, dorsal view, B third leg, arrow indicating cement gland and mid-femur inflation, inset showing enlarged femur of ovigerous female with ova; C, ten-segmented oviger, inset showing denticulated spine; D, chelifores with one segmented scape, chela fingers crossing at tips.

ovigerous, 2 juv. (QMS105869); Paratypes 1♂ with eggs, ♀ ovigerous, coll. Lee, Syntypes 2♂, 2♀ (QMS105870).

DISTRIBUTION. Known only from Rowes Bay, Townsville, Queensland, in 0.5m tidal height.

DESCRIPTION. Body tiny, leg span 5.6mm. Trunk without ornamentation, segments inflated, first two segments fully segmented, third segment lacking complete segmentation lines. Lateral processes glabrous, short, widely separated by twice their diameter, no ornamentation. Abdomen small, low, almost glabrous. Ocular tubercle low, rounded dome, large eyes filling entire tubercle, lightly pigmented. Neck distinct, moderately long, very narrow proximally, expanded distally. Proboscis short, semi globular, tapering to a small oral surface. Chelifores moderately small, scape one-segmented, about 2.5 × longer than wide, armed with three or four distal and lateral setae longer than or as long as scape diameters. Chelae with similar dorsal setae, fully formed with denticulate immovable finger with 6 well-formed teeth, movable finger without teeth. Fingers cross at tips. Ovigers typical for the genus, strigilis segments with rounded denticulate spines in the formula 6:4:4:4, terminal claw absent, fifth segment the longest, with tiny dorsodistal tubercle having two short setae. Legs long and slender, cuticle transparent; few setae, all shorter than segment diameter

exeept dorsodistal seta; tarsus very short, with one heel spine and 2-3 short setae; propodus slender, moderately curved with 4 heel spines and 10-12 shorter sole spines and setae; main elaw long, about 2/3 propodal length; auxiliary elaws long almost as long as daetyl. Single eement gland, extruding ventrally through a single pore eausing slight inflation at mid-femur.

Femule. Slightly larger, neek slightly longer than male, with latero-distal apophysis on fifth segment of oviger laeking in female, as typieal. Legs are similar except in ovigerous females where the femora are enlarged with ova in various stages of development.

Measurements. Holotype (in mm). Trunk length (ehelifore insertion to tip of fourth lateral proeesses) 0.64; trunk width (aeross seeond lateral proeesses) 0.27; proboseis length 0.21; abdomen length 0.15; third leg, eoxa I 0.09; eoxa II eoxa III, 0.13; femur 0.64; tibia I 0.55; tibia II 0.65; tarsus 0.05; propodus 0.25; elaw 0.13.

REMARKS. This new speeies is rather similar to *Callipallene tridens* Nakamura & Child, 1988. These similarities are seen primarily in the inflated posterior trunk segments of eaeh speeies. In both, the oeular tuberele is plaeed on a slight elevation and the segments are sutured the same way, and the third and fourth segments laeking the posterior sutures. Many speeies of this genus inflated posterior trunk segments but it is usually seen in juveniles, while the adult trunk segments are more slender. Many also laek the third trunk suture, as do *C. tridens* and *C. catulus*. The main differenees between *C. catulus* and *C. tridens* lie in the laek of the speeialised trident-shaped auxiliary elaws of *C. tridens*. *Callipallene catulus* also has longer and more slender appendages and different ehelae, whieh serve to distinguish the two speeies. *Callipallene catulus* is extremely tiny, almost smaller than any *Callipallene* speeies described, exeept *C. tridens*, whieh is possibly the smallest known speeies at 3.5mm in leg span (Nakamura & Child, 1988).

PHOXICHILIDIIDAE Sars, 1891

Anoplodactylus glandulifer Stock, 1954

Anoplodactylus spec., Calman, 1923: 289.
Anoplodactylus glandulifer, Stock, 1954: 16-17. Child 1982: 273-274; 1988: 58-59. Nakamura & Child, 1988: 813. Müller, 1990: 74. Child 1990: 331. Müller, 1992: 166, figs 27-30. Stock 1992: 94-95.Bamber, 1992: 193-194. Stock 1994: 59.
Anoplodactylus multiclavus Child, 1977: 593-596, fig. 4; 1979: 58, fig 19d; 1982: 272. Müller, 1992: 166.

MATERIAL. Rowes Bay, rocky band on algae *Cladophora prolifera* (Roth) in 0.5m, April-November 1998, 1♂ with eggs, 2♀ (QMS105873); 3♂, 3♀.

DISTRIBUTION. This speeies is fairly widely distributed throughout the Indo-West Paeifie, from the Red Sea to Kenya, Singapore, Hong Kong, the Marshall Islands, the Great Barrier Reef and also the Caribbean Sea (where it was deseribed as *A. multiclavus*).

REMARKS. This speeies is one of a group of over 20 in this genus with multiple femoral eement gland openings (Child, 1988: 293-294, for a partial key). Femora have from 2-5 tiny eups loeated dorsally, with the numbers varying among legs of the same male speeimen and also among speeimens of a single population. Otherwise, this speeies is quite robust, with lateral proeesses elosely set. Both ehelae fingers are armed with teeth, and the movable finger is longer than its partner. Hints of palp buds on the anterior side of the first lateral proeesses and a long propodal lamina are eharaeteristie of the speeies.

Anoplodactylus cribellatus Calman, 1923

Anoplodactylus cribellatus Calman, 1923: 285.
Anoplodactylus simplex Clark, 1963: 50-51, fig. 25A-F. Stock, 1979: 158. Staples, 1982: 461, fig. 2A-B, pl. 1. figs C-D. Bamber, 1997: 46-49, fig. 2.
Anoplodactylus perforatus, Nakamura & Child, 1983:289, 1988:813,1991:29. Bamber, 1997: 46-49, fig. 2.

MATERIAL. Cleveland Bay, Townsville, dredge sample, 3-15m depth, sandy-muddy bottom, 1998 2♀, (QMS105872) coll. J. Cruz.

DISTRIBUTION. The individuals here eolleeted would have been reported as *A. simplex* for whieh there were only two previous reeords from the east eoast of Australia (Clark, 1963; Staples, 1982; but see Arango, 2003). However, Bamber (1997) examined the Indo-west Paeifie *Anoplodactylus* speeies with very numerous eement gland pores eoneluding the synonymy of three speeies: *A. cribellatus* from the Andaman Islands, *A. perforatus* Nakamura & Child, 1983 from Japan and *A. simplex* from Australia. All speeimens found in rather shallow waters.

REMARKS. The speeimens eolleeted here agree with the deseription of *A. simplex* syn. Clark showing 22-30 eement gland pores, a short abdomen and elongate propodus without a typieal propodal lamina along its sole. After Bamber's examination of three similar speeies in whieh the number of eement glands pores overlap but the strueture of the legs and ovigers are

identical among them (Bamber, 1997) it is reasonable to report these specimens as *A. cribellatus* and not *A. simplex*.

Anoplodactylus tubiferus (Haswell)

Phoxichilidium tubiferum Haswell, 1884: 1032, pl. 57, figs 1-5.
Anoplodactylus tubiferus Cole, 1904: 288. Flynn, 1919: 79-81, pl. xx., figs 12-14, pl. xxi., fig. 15. Nakamura & Child, 1991: 32. Stock, 1994: 67.

MATERIAL. Cleveland Bay, Townsville, dredge sample, 3-15m depth, sandy-muddy bottom, 4♂, 1♀, (QMS105871) coll. J.Cruz.

DISTRIBUTION. This species was first described in 1884 and has been collected from Madagascar and the Persian Gulf to Australia, Philippines and Japan. It is known to inhabit different depth strata, from 2-235m.

REMARKS. The extremely long and conspicuous cement gland makes the males of this species easily identifiable. It has a single cement gland tube more than twice as long as the femur, protruding almost vertically. This species has a very tall ocular tubercle and abdomen, very long distal spines on the lateral processes, and sometimes dorsally on the trunk. These features facilitate the identification of *A. tubiferus* (Staples, 1982: 457-459, fig. 2C). The species shows a general elongate habitus shared with other species from the western Pacific. A key for this species can be found in Nakamura & Child (1983: 41-42).

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THE GREEN TURTLE, *CHELONIA MYDAS*, POPULATION OF RAINE ISLAND AND THE NORTHERN GREAT BARRIER REEF: 1843-2001

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European history of the use of Raine Island and nesting green turtles is reviewed. Results of a diverse mosaic of investigations of the reproductive biology of the nesting population of green turtles using Raine Island and the adjacent islands are presented. These studies have focused on defining the fundamental characteristics of the breeding population, with more in-depth studies being conducted elsewhere. Studies at Raine Island have defined the species composition, morphology of adults, eggs and hatchlings, hatching and emergence success, sources of mortality of adults, eggs and hatchlings as well as the nesting environment. ❐ *Green turtle, Raine Island, population history, Great Barrier Reef.*

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There are four major green turtle, *Chelonia mydas*, breeding concentrations in Australia: Capricorn - Bunker Groups and adjacent islands in the southern Great Barrier Reef (GBR); Raine Island - Moulter Cay and adjacent islands in the northern GBR; Wellesley Group - eastern Arnhem Land in the Gulf of Carpentaria; and, the northwest shelf of Western Australia. These appear to be the only major rookery areas for the Australasian region where significant population declines are not already in progress for this species (Groombridge & Luxmoore, 1989). Raine Island, Moulter Cay and the other sand cays of the northern GBR collectively support the largest remaining breeding assemblage of green turtles in the world.

While world-wide there were once many other *C. mydas* rookeries of the magnitude of Raine Island - Moulter Cay, there may now only be a few: Tortuguerro rookery of Caribbean Costa Rica; Ras al Had in Oman; Northwest Shelf of Western Australia. Australia and, in particular the GBR, is one of the last strongholds for a once flourishing species worldwide.

Within a few years of commencement of our tagging at Raine Island it became apparent that many of the turtles were migrating from feeding areas outside of Australia. In addition, large numbers of *C. mydas* were being hunted for food, both at the village level and for commercial market, within the feeding areas supplying turtles to the Australian rookeries. So, while there has been almost total protection of the nesting females at the GBR rookeries for many years, the population is under a large but imprecisely determined harvest pressure. In many areas this harvest targets large females but in Torres Strait gravid females migrating to breed are preferred where they are available. The pattern that has developed this century with turtle harvests in other countries is that marine turtle population numbers will crash following several decades of intense harvesting. Given that the large harvests that target the Raine Island turtles have only been operating in the past 2 or 3 decades, concern must be held for the future stability of this population. Improvements in our basic understanding of turtle biology and significant improvements in marine turtle management are surely needed in these times of declining turtle populations in Southeast Asia and the Western Pacific Region (Limpus, 1997). This is particularly so, given that sustainable management of marine turtle populations subjected to large scale harvests has not been achieved in the 300 years since the elements of our modern understandings of green turtle biology were first described by William Dampier in 1717 (Masefield, 1906).

The turtle research at Raine Island in the years 1975-1979 was initially part of exploratory studies by the Queensland Government Conservation Agency (currently called Queensland Parks and Wildlife Service [QPWS]) to map the species composition, size and distribution of marine turtle breeding populations in Queensland. At that time it became apparent that there was a lack of fundamental information required to effectively manage a marine turtle

population in the face of large scale harvesting and guarantee its long term continuity. During the period 1979-1985, the Queensland Turtle Research Project undertook the development of new methodologies to address marine turtle population dynamics. These included: tagging methodology to enable turtles to be recognised over decades rather than a few years (Limpus, 1992a); capturing techniques for studying the turtles in their home feeding areas (Limpus & Read, 1985a); methodologies for sexing and assessing the reproductive status of turtles in their feeding areas (Limpus, 1992b); genetics research to determine methods of recognising the distribution and number of genetically discrete breeding units within our *C. mydas* herds (Norman et al., 1994a); and mark-recapture studies to provide the quantified life table parameters including fecundity, growth data, survivorship and recruitment, (Limpus & Chaloupka, 1997; Chaloupka & Limpus, 2002) that are necessary for developing good models for describing marine turtle population dynamics (Chaloupka & Limpus, 1996; Chaloupka, 2002).

This latter issue of understanding population dynamics is vital if we are to manage our turtle herds on a sustainable basis in the face of large scale mortality from harvest and other sources.

Recognising the potential threats to the conservation of the GBR *C. mydas* breeding populations posed by large scale harvesting within the Australasian region, QPWS placed a priority on studies of *C. mydas* in 1985. An integrated set of field studies was developed, bringing together a team of researchers with diverse skills, to investigate the population dynamics of eastern Australian green turtles. The study commenced in 1986 and became fully operational in 1987. At the core of the study has been the simultaneous study of *C. mydas* at each of its three eastern Australian rookery regions and at a series of feeding areas distributed throughout eastern Australia.

For logistical considerations, Heron Island within the southern GBR nesting area was selected as the primary study site for in-depth research of the reproductive biology of *C. mydas*. Access to the major nesting beaches of the northern GBR has been more difficult because of the remoteness of Raine Island and Moulter Cay and large expense associated with maintaining on-site studies there. Therefore, studies at Raine Island were planned as short term sampling studies rather than total season tagging census studies with an emphasis on quantifying those parameters considered to have unique values for Raine Island. It was also recognised that results of past intense studies from Bramble Cay in the extreme northern GBR would supplement results for the Raine Island area.

It is in the context of this complex mosaic of diverse, yet complementary investigations, that the present study of the *C. mydas* nesting population at Raine Island and adjacent rookeries is presented. It is part of a planned, long-term, integrated regional study of green turtles in the Australasian region designed to provide sound information that can assist in improving the conservation management of *C. mydas*.

METHODS

Data for this study was drawn from the historical and published accounts of Raine Island, from the results of interviews with fishermen and others who visited the island in recent years and from field studies undertaken at Raine Island in the period 1974 to February 2002. While the principal emphasis will be on Raine Island and its turtle population, the green turtle populations at Moulter Cay and the other islands in the northern Great Barrier Reef will also be considered.

SPECIES IDENTIFICATION. Turtle species identification was made from the available keys (Bustard, 1972 and Cogger & Lindner, 1969). These data have been modified into the field key used in the QPWS Queensland Turtle Research (QTR) Project (Limpus, 1992c).

TAGGING. Table 1 summarises the types of tags and their positions of application used in the present study. All tags were self-piercing self-locking flipper tags, serially numbered with a return address on the opposite side to the number. Monel tags: National Band and Tag Company, Kentucky; style 1005, #49 and #19; weight = 7g. Three series of monel tags were used, each being identified by the prefix to the tag number (Table 1). Titanium tags: Stockbrands Company Pty Ltd, Western Australia; #standard; weight = 4g, commercially pure titanium, grade 125, 1mm thick. These titanium tags have a locking mechanism resembling that of the monel tag style 1005 #19. Return address was to Queensland Parks and Wildlife Service. All titanium tags carry a T, I or K prefix to the tag number.

Tags have been applied to various positions on the trailing edge of the front flippers. Standard tagging positions (Limpus, 1992a) have been

TABLE 1. Summary of tag designs, return addresses, tagging positions and the number of tags applied per turtle. See Limpus (1992a) for further definitions. * Recaptured turtles from previous seasons or other studies were double tagged L3 and R3.

Tag series	Metal type or style	No. tags per female	Tagging position	Return address
No prefix	Monel #49	1	L1	Applied Ecology Pty Ltd
A prefix	Monel #49	2	L1 & R1	Applied Ecology Pty Ltd
X prefix				QPWS
Under X35000	Monel #49	1	L1 prior to 1978	
		1	L3 after July 1978	
Above X35000	Monel #19	1*	L3 after 1979	
T prefix, I prefix, K prefix	Titanium	1*	L3	QPWS

coded as follows: L = left front flipper; R = right front flipper; 1 = tag applied immediately distal to phalange 5 (after Bustard, 1968); 3 = tag applied through or adjacent to the most proximal axillary scale (= axillary tagging scale, Limpus & Reed, 1985a). Thus a tag can be described as having being applied at the L1, L3, R1 or R3 position.

COUNTING TURTLES. Counts or indices of the number of turtles ashore per night were established in one of the following ways:

a) Tally count. An instantaneous count of all turtles was conducted by several persons walking line abreast across the beach, for one circuit of the island between 2000-2300hr (a tally count usually took 40-60min. to complete). Counts commenced at least one hour after turtles had swimming access to the nesting beach across the reef flat after dark. During the summer nesting season the tides are such that on most of the nights, the majority of the turtles for the night will have beached within a few hours of darkness. A green turtle rarely lays and returns to the water in less than 3hr on the beach.

b) Tagging census. A count of all turtles ashore for the night based on tagging records. This was only attempted during periods of low density nesting (<400 females ashore per night).

c) Track count. A count of all turtle tracks for the night by species, based on a count just after dawn of the tracks that start below the previous nights high tide mark. Each track equals an 'emergence' and a 'return' component. This method has only been applicable on nights with a low density of turtles. At Raine Island, if there is an error it will usually involve some under-estimation. At localities visited for a single day only, tracks accumulated over several nights may be indistinguishable, resulting in the potential for overestimates.

d) Stepping index. Commencing with the Raine Island during the 1987 summer expedition, the opportunity was taken to evaluate nesting density equivalents to old reports from fishermen who spoke of having walked across the backs of many nesting turtles without having to step down onto the sand. When dense aggregations of nesting turtles were encountered on Raine Island beach between 2100-2400hrs, an agile average sized person stepped from turtle to turtle for as many steps as possible without stepping onto the beach. The number of turtles stepped on is defined as the stepping index of the nesting density. This was repeated at several places around the island on each night. It was not attempted on nights with rain when the carapaces were slippery.

MEASUREMENTS OF TURTLES, EGGS AND NESTS. The adult turtles were measured as follows. Curved carapace measurements were taken with flexible fibre-glass tape measure (±0.5cm prior to 1983; ±0.1cm thereafter) stretched tightly from edge to edge. Straight carapace measurements were taken with a steel tape measure (±0.1cm) and large wooden dividers with recurved ends. Measurements of standard length were made along the midline from the anterior skin-carapace junction to the apex of the posterior midline notch between the supracaudal scutes (curved and straight carapace length = CCL and SCL, respectively). Width was measured at the widest part of the carapace (curved and straight carapace width = CCW and SCW, respectively). These measurements correspond to those used in other major studies of marine turtles in Australia (Limpus, 1971; Bustard, 1972; Limpus et al., 1983a,b, 1984a). To allow for comparison with turtle studies in other areas, adults were also measured for the standard length measurement used by Professor Archie Carr, i.e. from the most anterior projection of the carapace over the shoulder to the tip of the most posterior projection of the carapace (= Carr's straight carapace length [CSCL] [Carr and Ogren 1960]; this is not a midline measurement). Adult turtles were weighed on Salter dial balances (±0.5kg). Females were weighed after completion of oviposition.

Clutches were counted and eggs measured within 2 hours of being laid and with a minimum of rotation and vibration of the eggs (Limpus et al., 1979; Parmenter, 1980a). Eggs and hatchlings were measured for mean diameter and straight carapace length, respectively, with vernier slide callipers (±0.01cm) and weighed on Pesola spring balances (±0.5g). No more than 10 eggs or hatchlings were measured per clutch. The emergence success of a clutch was assessed by excavation of the nest and recording the fate of the eggs by six classes: undeveloped = egg contained no obvious embryo (< Stage 17 of Miller, 1985); unhatched = egg contained a recognisable embryo (>stage 17 of Miller, 1985); predated = egg broken by crab; dead in nest = hatchling died after hatching, but below the beach surface; live in nest = hatchling was alive, but had not emerged from the nest (groups of live hatchlings just below the surface and not tangled in vegetation were counted as having emerged); emerged = hatchlings which successfully hatched and escaped from the nest to the beach surface (Limpus et al., 1983a,b).

Nest depths were measured with a fibreglass tape measure (±0.5cm) from the beach surface to the top of the upper most egg and to the bottom of the egg chamber (sinsu Bustard & Greenham, 1969).

Sand temperature was measured with a mercury-in-glass thermometer (±0.5°C) inserted horizontally into the sand 50cm below the surface. Core body temperatures of nesting turtles were measured by the Mrosovsky & Pritchard (1971) method. This required catching an egg immediately as it was oviposited and inserting a quick reading mercury-in-glass thermometer into the middle of the yolk.

NESTING SUCCESS AND CLUTCH DESTRUCTION. Two methods were used for estimating nesting success, here defined as the proportion of females ashore for the night that lay a clutch.

a) Following individual turtles. Nesting turtles were selected at random as they came ashore on the western end of the island at night and were followed until they returned to the sea. Their nesting success was recorded. This method of measurement was time consuming, as it required a person committed to maintain observation of an individual turtle, irrespective of how long it was ashore. Usually only one turtle could be followed on any one night. Each turtle had to be followed at such a distance that she did not respond to the observer's presence.

b) Using fixed sampling sites. Standard study sites were chosen on opposite sides of the island. Unless otherwise stated, each site was 100m in length and extended from the water line to the cliff line. On selected nights, within one or both of these sampling sites, a count was made of the number of turtles which entered the sampling site from across the waterline, the number of clutches laid within the area by these turtles, and the number of existing clutches that were dug into by the nesting turtles. Each data set required one person monitoring a sampling site for approximately 14hr continuously commencing at about 1600hr. Two rate parameters can be calculated from these data: nesting success (NS) and clutch disturbance (CD) by nesting turtles.

NS = Number of clutches laid / total number of turtles entering area

Nesting success was calculated on the number of turtles crossing the high water line on the assumption that lateral movements into and out of the sampling sites along the beach by turtles attempting to nest are approximately random and will cancel each other.

CD = Number of existing clutches disturbed / Number of new clutches laid.

When a turtle was found digging into an existing clutch, irrespective of where it was on the island, the number of eggs dug from the nest was counted. These counts provide a measure of the egg mortality per clutch disturbed (EMpDC) by nesting females. When compared to the mean clutch count for the rookery, this egg destruction can be expressed as the proportion of a clutch destroyed per clutch laid (clutch equivalent egg mortality = CEEM) CEEM = EMpDC × CD / mean clutch count.

ESTIMATION OF THE SIZE OF THE ANNUAL NESTING POPULATION.

Petersen Estimate. If a sample of the turtles ashore on Raine Island at night is marked so that they can be recognised in the water over the following days, and if the marked turtles are uniformly distributed among the unmarked turtles in the waters surrounding Raine Island, then mark-recapture data can be analysed using the Petersen estimate with Bailey's correction (Caughley, 1977) to provide an estimate of the number of adult green turtles in the waters surrounding Raine Island at that time.

In a population where M animals are marked

out of a total population of N animals and m marked animals are recaptured in a subsequent sampling of n animals:

$$N = M(n+1) / (m+1)$$

This estimate has a formal standard error of approximately:

$$SE = [M^2(n+1)(n-m) / (m+1)^2(m+2)]^{1/2}$$

The principal assumptions made in using this method are: 1) the marked turtles are uniformly distributed among the unmarked turtles that form the Raine Island breeding assemblage within the internesting habitat on that day; 2) there is a negligible rate of loss of the mark between marking and recapture; 3) the marks are easily seen on the swimming turtle; 4) all the females aggregated on Raine Island Reef are there to breed i.e. there are insignificant resident non-breeding female and immature male populations on Raine Island Reef; 5) there is equal probability of the tagged and untagged turtles moving outside the sampling area; and 6) there is negligible mortality of the adult turtles during the sampling period.

Two methods have been used to mark the Raine Island nesting turtles for mark recapture studies.

1) Standard turtle tags. Within a study trip, after several nights of tagging the nesting females on the beach, a search of sections of the surrounding Raine Island Reef was made to locate, count and visually check females for the presence or absence of a tag. Only those females checked were counted. Those seen in the distance but not checked were excluded from calculations. Monel tags applied to the L1 or R1 tagging positions (towards the distal ends of the front flippers) were readily visible on a swimming turtle. In 1979 the place of application of the metal tags was changed to the axillary area of the trailing edge of the front flippers (L3 or R3 tagging positions) to improve tag retention. This axillary tag placement resulted in a reduced visibility of the metal tag on the swimming turtle, especially for those not viewed at very close range. The poor retention rate of monel tags (Limpus, 1992a) made it unlikely that there was a significant proportion of remigrant turtles that would be counted in the internesting habitat as part of n but which were not part of M.

2) Paint marks on the carapace. Commercially available paint was use to mark the dry carapace of nesting turtles on Raine Island at night. Paint marks were at least 10cm long, applied by a 2.5cm wide brush or by a pressure pack can, were applied to the dry carapace of nesting turtles on Raine Island at night. Oil based enamel paints were used initially. Commencing in 1995, the paint used to mark the turtles was changed to white Wattyl Airpave™ (504-40100. BN:-451695-09) paint applied as single stripes with 5.0cm wide brushes. On the first night of painting, the stripes were longitudinal along the midline, on the posterior half of the carapace. If turtles were painted on a second night in the same trip, those marks were transverse stripes on the posterior half of the carapace. A turtle was selected for painting if: the carapace was dry; the carapace did not have a thick coating of algae; and the turtle was inland of the beach crest, and well within the nesting habitat. When applied in these conditions, the paint was observed to adhere well to the carapace surface for at least 48hr (enamel paint) or 96hr (Airpave). Using this marking system, the goal was to paint-mark as many turtles as possible on the island in a single night. A search was made for marked turtles among the turtles in the waters surrounding the island on subsequent days. Turtles seen were recorded by species and tail length. Those with long tails were scored as male, adult-sized short tailed turtles were scored as presumed adult female and those smaller than adult female (CCL <90cm for *C. mydas*; CCL <75cm for *E. imbricata*) were scored as immature (Limpus & Reed, 1985a; Limpus, 1992b). Counts were made of those females for which the presence/absence of the tag/paint mark could be definitely established.

Two types of in-water searches were made for the turtles.

1) Diving transects. Transects using SCUBA, or snorkel, were swum along the reef edge above the 10m depth terrace. Written records were kept on waterproof paper. During a diving transect, two persons were in the water, one counting and one on the lookout for sharks. The lookout carried a hand spear for warding off sharks and the recorder carried a line attached to a buoy at the surface. A third person maintained a dinghy adjacent to the buoy for rapid retrieval of the divers from the water, if required.

2) Speedboat transects. On days with clear, relatively calm water, transects were driven across the reef flat at the upper part of the tidal cycle and along the outer edge of the reef in search of turtles, using an outboard powered dinghy. By driving adjacent to the swimming turtle, it was possible to score it by species/size/sex/mark presence. A minimum of two persons were required in the speedboat, one recording and the other driving and counting. The

acceleration capability of the speedboat was vital. The boat had to be able to accelerate quickly to reach the turtle before its swimming disturbed others nearby, or before it escaped to deep water. Boats about 4-5m in length, powered with a 40-60HP outboard motor were best suited to this use in shallow water. Conventional 3.5m aluminium dinghies and inflatable dinghies fitted with 10-15HP outboard motors proved unsuited to the task.

In high density nesting seasons, it was impossible to obtain an absolute measure of the nightly number of females emerging on Raine Island, so the mean nightly tally count has been used in lieu of the number of turtles emerging per night. This under-estimates the actual number of turtles emerging nightly.

MORTALITY STUDIES. The number of dead and moribund turtles at each studied rookery was recorded on arrival. Subsequent adult mortality, particularly on Raine Island, was recorded daily. Previously encountered carcasses were identified by flagging them with coloured surveying tape or by paint marks. Moribund turtles were rescued where possible, especially those that had fallen onto their backs. These rescued turtles were counted as mortalities for the purposes of the study.

In December 1989, a group of turtles that had remained on the beach until at least mid-morning, and were in a location where all such turtles died naturally of heat exhaustion were selected for detailed study. Changes in core body temperatures of these moribund turtles was assessed by inserting a cannula through the inguinal pocket anteriodorsally, to the movement arch of the hind leg (as is done during laparoscopic examination of turtles). The cannula provided access to the abdominal cavity and allowed a thermometer probe, attached to a 50cm rod, to be inserted to lie above the gut and ventral to the lungs just posterior to the heart. The lead and readout unit were taped to the carapace and the turtles were allowed to move undisturbed on the beach until they died. Temperatures were read at half hourly intervals. Necropsies of these turtles confirmed the correct placement of the probes, and that no damage had been done to organs or blood vessels. The insertion of the probes did not contribute to the death of the turtles.

The daily census of dead and moribund turtles was conducted between 1500 and 1900hr. On occasion, freshly dead turtles were necropsied to assess oviducal contents and ovarian condition.

TABLE 2. Circumference of sand islands used by green turtles for nesting in the Far Northern Great Barrier reef. Circumference was measured at approximately mean high water spring tide level using a pedometer.

Island	Date	Circumference
Raine Island	1977 Dec	1799m
	1978 Dec	1764m
	1980 Jun	1808m
Moulter Cay	1976 Dec	1179m
	1977 Dec	1138m
Maclennan Cay	1978 Nov	885m
No. 7 Sandbank	1976 Nov	1755m
No. 8 Sandbank	1976 Nov	1816m
Bramble Cay	1977 Dec	748m

In December 1989 the core body temperature of some dead turtles was measured during necroscopy.

RECRUITMENT RATE STUDIES. We have introduced a new method for marine turtle studies for quantifying recruitment of new adults into the breeding population. Traditionally, recruitment of new adults into the breeding population has used long term total tagging census to identify all turtles with a past breeding history. After a total tagging census at a nesting beach that spans several mean remigration intervals, turtles that have not been previously tagged are identified as new recruit (Hughes, 1989; Richardson & Richardson, 1982; Limpus, 1985; Limpus et al., 1984b; Parmenter & Limpus, 1995). This has been an inappropriate method for the Raine Island population given the difficulties in tagging the entire nesting population, even in a single year. Within foraging area studies in eastern Australia, marine turtles have been assessed for recruiting into the adult breeding population using ovarian features, in particular scoring for the presence or absence of corpora albicantia. A corpus albicantium is a healed corpus luteum and a corpus luteum is formed by the release (ovulation) of a mature follicle from the ovary. The presence of corpora albicantia indicates that a female has bred in a past nesting season. Similarly the absence of corpora albicantia on the ovaries of a female with oviducal eggs indicates that she has not bred in a past breeding season and that she is in her first breeding season. Therefore the absence of corpora albicantia in the ovaries of females that have recently ovulated can be used to identify those females that are new recruits to the breeding population (Limpus & Limpus, 2003).

Ovaries were examined by direct examination via necropsy of nesting females that had freshly

died on the nesting beach or by endoscopy (Limpus & Reed, 1985b; Limpus et al., 1994c). For endoscopy of the breeding female, it was necessary to examine females ashore as they completed the laying of a clutch. Otherwise the presence of oviducal eggs made it very difficult to view the surface of the ovary clearly. Limpus & Limpus (2003) provide a key for scoring sex, maturity, breeding status and recruitment from gonad examination.

GENETIC STUDIES. Tissue samples were collected for genetic research in a variety of ways. Non-sibling hatchlings were sampled by collecting one hatchling per clutch from clutches which emerged within a two week period at any given rookery (Norman et al., 1994a). This ensured that no more than a single hatchling was sampled from any one female within the breeding season. To ensure that individual adult turtles were sampled only once, adult turtles with unique tag numbers were sampled for either muscle, blood or skin (Norman et al., 1994b; FitzSimmons et al., 1995). The methods for genetic analysis are described in these separate papers.

RESTRICTIONS ON STUDIES AT RAINE ISLAND. Raine Island and the adjacent islands have proven to be logistically difficult for long term and exrended period study due to remoteness. The number of personnel that can be deployed on the island for the turtle studies has been limited because of the need to minimise disturbance to the nesting colonies of sea birds that Raine Island supports.

The first trips to Raine Island for this study were opportunist. The Queensland Parks and Wildlife Service (QPWS) study was supported in part by research grants from the Australian National Parks and Wildlife Service during 1976-1979. In 1977 and 1978 the expeditions to Raine Island were supported by Applied Ecology Pty Ltd (AE) who provided a vessel to visit the island. In 1979 with the aid of a WWF grant a study of seas birds at Raine Island was commenced and one turtle researcher was able to accompany the bird study group. In 1981 the Raine Island Corporation became responsible for the conservation of Raine Island and commenced funding research expeditions to Raine Island. From 1981 to 1985 the Raine Island Corporation chose to place an emphasis on sea bird studies and the turtle research team was limited to one person on the island in any one trip except during December 1984, when 2 persons were present for the turtle studies. The sea bird research team assisted with turtle tally counts and incidentally with the other aspects of the study. Since 1985 the Raine Island Corporation has reduced its emphasis on sea bird studies at Raine Island and has funded the summer expeditions primarily for the turtle research with teams of 4-5 persons per trip. To maximise the data gathered on a trip, small numbers of other islands were surveyed for marine turtle nesting during transit to and from raine Island. Thus from 1975-1989, the majority of the islands between Princess Charlotte Bay and Cape York were surveyed at least once. These data provided a measure of the regional distribution of marine turtle nesting by species.

CLIMATE DATA. Regional rainfall and temperature data from the three long-term Coral Sea weather stations nearest to Raine Island (Torres Strait, Willis Island and Lockhardt River) were obtained from the Australian Bureau of Meteorology.

STUDY AREA

RAINE ISLAND. Raine Island (11°36'S, 144°01'E) is a coral cay on the leeward north-western end of a small detached reef on the outer edge of the northern GBR (Fig. 1). The island is approximately 80km offshore from the mainland, north east of Cape Grenville. Raine Island Reef lies in the eastern approaches at the Raine Island Entrance, a deep water passage through the outer barrier reef. The reef rises abruptly out of deep water with near precipitous cliffs to a narrow terrace at approximately 8m depth and is topped by an approximately uniform height reef flat that dries at the lower tidal ranges.

Raine Island, as described in recent times (Warham, 1977; Stoddart et al., 1981; King, 1986), approximates to the island as it was described in 1843 (Jukes, 1847). The island is approximately 1800m in circumference at the mean high water spring (HWS) tide level (Fig. 2, Table 2). The beach substrate is a white calcium carbonate sand composed of mostly fragmented coral and mollusc and foraminiferan skeletons (= star sand). Turtle and sea bird bones are obvious but at low density within this sand. The beach width measured from the high tide line to the low cliff line of the central rock platform varies from approximately 15m near the beacon to 90m on the southern side. Storms wash over the outer beach rim to flood the beach depression, as indicated by accumulated pumice in the floor of this depression.

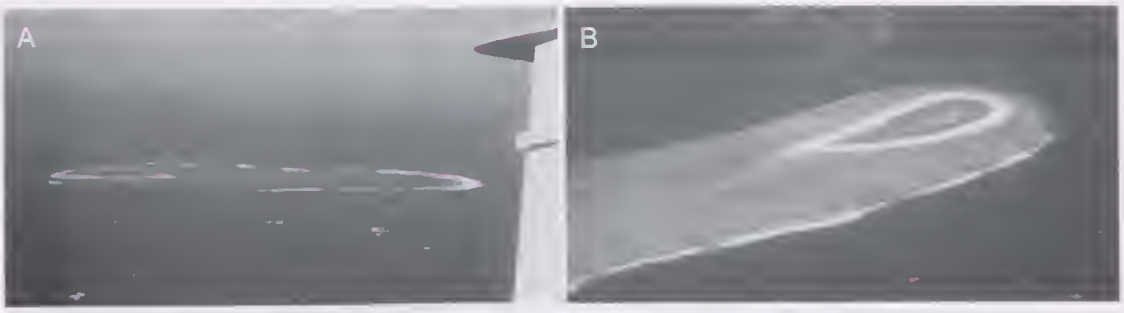

FIG. 1. Raine Island lies on the north-western end of Raine Island Reef. This small detached reef outside the main outer barrier reef marks the eastern boundary of the Raine Island Entrance. (8 April 1980). A, Raine Island and its reef, viewed looking north. B, this view of Raine Island shows a reduced beach vegetation cover outside the cliff line.

The island is devoid of trees. The inland portion of the beach is covered by grasses and herbs that vary in density and extent from year to year (Fig. 3). In breeding seasons with high density turtle nesting, the beach can be completely dug-over almost nightly and, as a result, can be essentially devoid of surface vegetation, e.g. following the 1974, 1984 and 1996 breeding seasons (Fig. 3A,F). Following such dense nesting seasons, the surface vegetation regenerates during and following the wet season, in the early to mid year. In a low density breeding season, there may be little disturbance to the beach vegetation (Fig. 3C) and it may be up to 0.5m high and extend over a half of the beach width at the commencement of the wet season. On all visits, the beach surface was uneven and cratered with turtle body pits of varying age.

The typical water line to cliff tracsect on the island, demonstrates a beach crest as an unvegetated outer ridge approximately 1 m above the mean HWS tide level. From this ridge the beach slopes downward into a depression before again rising to the base of the cliff line edging the central rock platform. The beach depression encircles the island except for a narrow rocky area adjacent to the tower. The floor of the beach depression can be up to 1 m below the outer beach ridge (i.e. at approximately the same horizontal level as the mean HWS tide) and slopes upwards in the seaward direction by as much as 13°.

The cliff line around the central rock platform (Figs 3, 4) ranged 1-2m in height and was usually a barrier to turtles climbing from the beach onto the surface of the central platform. At times, nesting turtles at the base of the cliff threw up sand rampways that provided temporary access onto the central platform by other nesting turtles. The position of the ramps constantly changed in high density nesting seasons as turtles dug away some ramps and formed others. These ramps provided access to the raised surface of the rock platform, especially in years of high density turtle nesting. This resulted in digging turtles creating patches of disturbed vegetation and bare sand on the adjacent rock platform surface adjacent to natural ramps (Fig. 3A). From time to time, nesting turtles would also undermine sections of the cliff to form small caves under the edge of the central platform.

The central rock platform consists of a cemented phosphatic limestone and has an approximately horizontal upper surface approximately 2m above the HWS tide level. A vegetated sand ridge of uncemented calcareous sand, rising to a variable height up to approximately 5m above HWS tide level and covered with grass and herbs, rims the rock platform and surrounds the central depression (Fig. 2). The floor of the central depression is the upper surface of the phosphatic limestone platform and has been modified by past guano mining.

MOULTER CAY. Moulter Cay, formerly called Pandora Cay (11°27'S, 144°00'E) (Fig. 5A), is a vegetated sand cay on the extreme outer barrier of the Great Barrier Reef, lying 14.5km north of Raine Island about 82km from the mainland coast at Cape Grenville (King et al., 1983b). The island measured approximately 1150m in circumference at the HWS tide level (Table 2). The calcareous sand beach was of very similar composition to that of Raine Island. The island had an outer unvegetated and an inner vegetated portion similar in width, elevation and topography to that of Raine Island. The small central rock platform of phosphatic limestone is partially bordered by a low cliff less than 1 m high

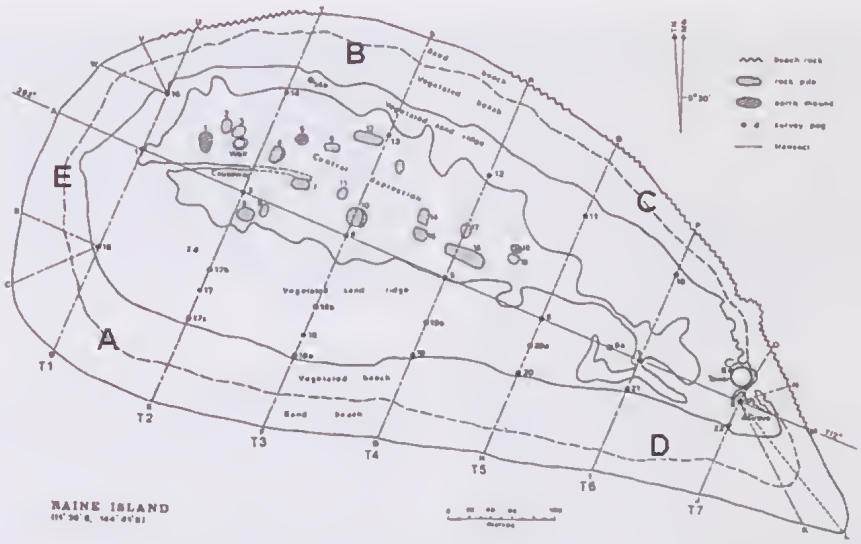

FIG. 2. Map of Raine Island, prepared by the late Brian King, showing the 100m interval grid lines. Study sites, 100m wide, for quantifying nesting sueeess and elutch disturbanee are designated by letters A to E.

at its maximum. As a result of this ineomplete and low elevation cliff, no part of this island is proteeted from nesting turtle incursion. In the less dense turtle nesting seasons and following the wet season, the rock platform and the inner beach area has by a grass and herb coverage to approximately 0.5m high. There have been no trees established on this island in historie times.

MACLENNAN CAY. Maclennan Cay (11°22'S, 143°48'E) is a very small vegetated sand cay on a small reef inside the outer barrier of the GBR 32km northwest of Raine Island (King et al., 1983a) (Fig. 5B, Table 2). Its elevation is approximately 0.5m above the mean HWS tide level. The sand substrate of the island resembles that of Raine Island and Moulter Cay but there is no central rock platform. It is sparsely vegetated with grass and herbs and does not have established trees. The island is frequently washed over by storm surges.

NO.7 SANDBANK. No.7 Sandbank (13°27'S, 143°59'E) is a small unvegetated sand cay on the extreme outer barrier of the Great Barrier Reef approximately 37km east of the mainland at Cape Sidmouth and 7km south southeast of No.8 Sandbank (King & Limpus, 1983) (Fig. 5C, Table 2). The beach is composed of uncemented calcareous sand rising to less than 1m above HWS. The island does not have a central rock platform. The island has been devoid of trees during historieal times.

NO.8 SANDBANK. No.8 Sandbank (13°22'S, 143°58'E) is a small vegetated sand cay on the extreme outer barrier of the Great Barrier Reef approximately 35km east of the mainland at Cape Sidmouth (King et al., 1983e) (Fig. 5C, Table 2). As with No.7 Sandbank, the beach is composed of uncemented calcareous sand rising to approximately 1m above HWS. There is no central rock platform on the island. The central portion of the island is covered with grass and herbsand the island has been devoid of trees during historical times.

GENERAL OBSERVATIONS ON THE OUTER BARRIER CAYS.

Trees. Seedling trees naturally germinated from beachwashed seeds (including *Barringtonia asiatica*, *Cocos nucifera* and *Nypa fruticans*) (Fig. 6) were found on the outer beach rim of Moulter Cay in December 1977 and Raine Island in December 1978. By December these seedlings were stressed and dying in the dry substrate of the outer beach rim. In most summers nesting turtles destroy any surviving plants on the outer beach rim of these islands. Any young tree that survived the digging of the nesting turtles would be used by perching sea birds and probably killed as a result.

Although Raine Island has been devoid of naturally occurring trees, some have been planted at various times by crews of passing boats, commencing with the visit of HMS *Fly* (Jukes,

FIG. 3. Annual fluctuations in beach vegetation cover of Raine Island. Southern beach looking towards the beacon. A, 1974-75 breeding season, 1 March 1975. The beach is almost totally devoid of vegetation. Adjacent to sand rampways that gave access to the top of the rock platform for nesting turtles, the vegetation above the cliff line is also greatly reduced. B, 1976-77 breeding season, 3 December 1976. C, 1977-78 breeding season, 5 December 1977. This view illustrates the low level of disturbance of beach vegetation that can occur in years of very low density turtle nesting. D, 1978-79 breeding season, 2 December 1978. The same log is in the foreground as in B. E, 1980-81 breeding season, 5 December 1980. F, 1984-85 breeding season, 19 December 1984. This view illustrates the extreme level of disturbance of beach vegetation that can occur in years of very high density turtle nesting.

1847). The BBC documentary *Zoo Quest: The Birds of Paradise II. Raine Island* documents one such planting in July 1957. These trees have not survived in the long term. On the last occasion, six coconut palms (*Cocos nucifera*) were planted on the western sand dune of the central rock platform during 1980. Since 1976, any coconut trees found planted on these islands have been removed by QPWS staff.

Vertebrates. There are few species of animals resident on these islands that have an impact on the marine turtles. These outer barrier cays support no native terrestrial mammalian or reptilian inhabitants, except for Bramble Cay which supports a gecko and an endemic native

FIG. 4. Margin to the phosphatic limestone platform, Raine Island adjacent to the beacon where the rock platform had a well defined cliff margin.

rodent, *Melomys rubicola*. This is a small herbivorous rat that does not prey on turtle hatchling or their eggs (Limpus et al., 1983d). The gecko is *Hemidactylus frenatus*, a small insectivorous lizard that was probably introduced with the building materials or food parcels supplied to Bramble Cay during the 1970s when it was a research study site and egg collection site for the Torres Strait turtle farms. Goats were released onto Raine Island in the 1840s but disappeared from the island sometime late last century (Stoddart et al., 1981).

The extensive avifauna of these outer barrier coral cays has been reviewed in recent years: Raine Island (King, 1986), Moulter Cay (King et al., 1983b), Maclennan Cay (King et al., 1983a), No.8 Sandbank (King et al., 1983c), No.7 Sandbank (King & Limpus, 1983). However, most of the sea bird species, and in particular those that occur in very high density are not predators of the turtles. Observations of bird predation of the turtle hatchlings will be discussed in the section dealing with hatchling predation.

An estuarine crocodile, *Crocodylus porosus*, was observed at Raine Island on one occasion; it is commonly seen in low numbers on the inner shelf islands (Limpus, 1980c) and has been recorded preying on marine turtles elsewhere (Limpus et al., 1983b).

Invertebrates. Terrestrial crabs, all of which recruit to the islands from aquatic larval stages, have been scarce on Raine Island. Two species of ghost crab, *Ocypode cordimana* and *O. ceratophthalma*, occur at low density. These species occur on almost all islands in this area and have been recorded preying on turtle hatchlings and eggs. *O. pallidula* was collected from No.8 Sandbank. Two species of terrestrial hermit crab occur on these outer barrier reef cays. *Coenobita rugosus*, has been found at low density on Raine Island, Moulter Cay and No.8 Sandbank and in high density on No.7 Sandbank. The larger reddish coloured species, *C. perlatus* has been particularly abundant on No.7 Sandbank. These *Coenobita* spp. have not been observed interacting with the turtle hatchlings or eggs although *C. perlatus* is large enough to prey on hatchling turtles.

Oligochaete worms were recorded among hatched and unhatched eggs in nests at Raine Island in January 1997, December 1999 and December 2001. Specimens (N39131) collected 29 January 1983 by B. King were lodged with the Queensland Museum.

Climate Data. The north-western Coral Sea regional climate recorded at the three Bureau of Meteorology weather stations in closest proximity to Raine Island is characterised by relatively uniform maximum and minimum air temperatures year round. The warmer months coincide with a distinct summer wet season from December to April (Fig. 7). Mean monthly daily air temperatures are above 25°C year round and the mean monthly maximum air temperature did not exceed 35°C.

Eastern Australia and the Coral Sea region are subject to considerable variability in annual climate. This is illustrated by the variability in the monthly Southern Oscillation Index (SOI) (Fig. 8). Region rainfall, which has impacts on marine turtle nesting (Limpus et al., 2001), is under the influence of the regional climate fluctuations. Periods with a negative Southern Oscillation Index (SOI) are usually characterised by low rainfall while positive values are usually associated with elevated rainfall levels (Couper-Johnston, 2000). Examination of SOI fluctuations over the last 31 summers (Fig. 8) indicates that during the last six summers (since1996) there has been an atypical sequence of wet seasons. Indeed, based on positive SOI values, Raine Island since 1996 should have been exposed to 5 of the 6 wettest summers in the last 25yr (Figs 7, 8). It has been during this same period that flooding of the nesting habitat has become an obvious and regular event at these northern GBR rookeries. Photographs (Fig. 9A,B) demonstrate clearly that the water table can rise higher than the depth at which the turtle eggs have been laid. At this time we are not prepared to speculate as to whether this pattern of more regular wet summers is the result of long term climate fluctuation or of global warming (Manton et al., 2001).

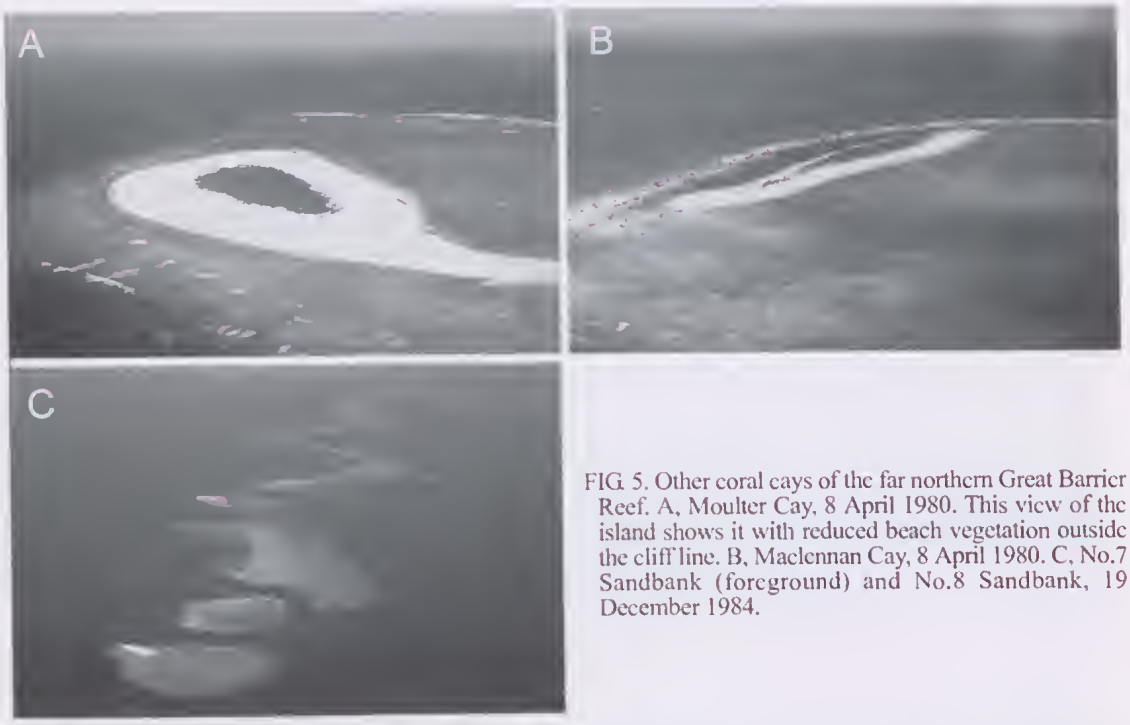

FIG. 5. Other coral cays of the far northern Great Barrier Reef. A, Moulter Cay, 8 April 1980. This view of the island shows it with reduced beach vegetation outside the cliff line. B, Maclennan Cay, 8 April 1980. C, No.7 Sandbank (foreground) and No.8 Sandbank, 19 December 1984.

HISTORICAL REVIEW OF PRE-1974 OBSERVATIONS OF TURTLES IN THE RAINE ISLAND REGION

The Raine Island Entrance from the Coral Sea through the Great Barrier Reef to Torres Strait was the focus of considerable navigational activity during the early to mid 19th Century. This, along with the large green turtle and sea bird populations associated with the adjacent islands (Raine Island and Moulter Cay) has resulted in numerous visits to the region by early Australian explorers, historians, sailors and naturalists. As a consequence there has been a considerable volume of natural history writings and observations on these islands.

FIG. 6. Seedling coconut palm, *Cocos nucifera*, growing on the outer beach rim of Moulter Cay, 3 December 1977.

Raine Island and adjacent Moulter Cay support one of the few remaining large breeding aggregations of *Chelonia mydas* in the world. In most areas where the species has bred in abundance in the past, the breeding populations have been greatly reduced, or taken to extinction by over harvesting at places such as Grand Cayman Island, Bermuda and Reunion Island (Groombridge & Luxmore, 1989). The current status of the turtle population that nests at Raine Island and Moulter Cay will be, in part, a function of the past history of human utilisation of the turtles and the islands. The following review of marine turtle records from these islands provides an historical context against which results of recent research can be compared and future change assessed.

The Queensland Turtle Research Project expanded to include systematic studies of the Raine Island *Chelonia mydas* rookery during the 1974-1975 breeding season. This then has been taken as the end point of the historical review of marine turtles in the Raine Island area. In this review, information has been brought together from diverse sources: published accounts of visits to the islands, interviews with fishermen

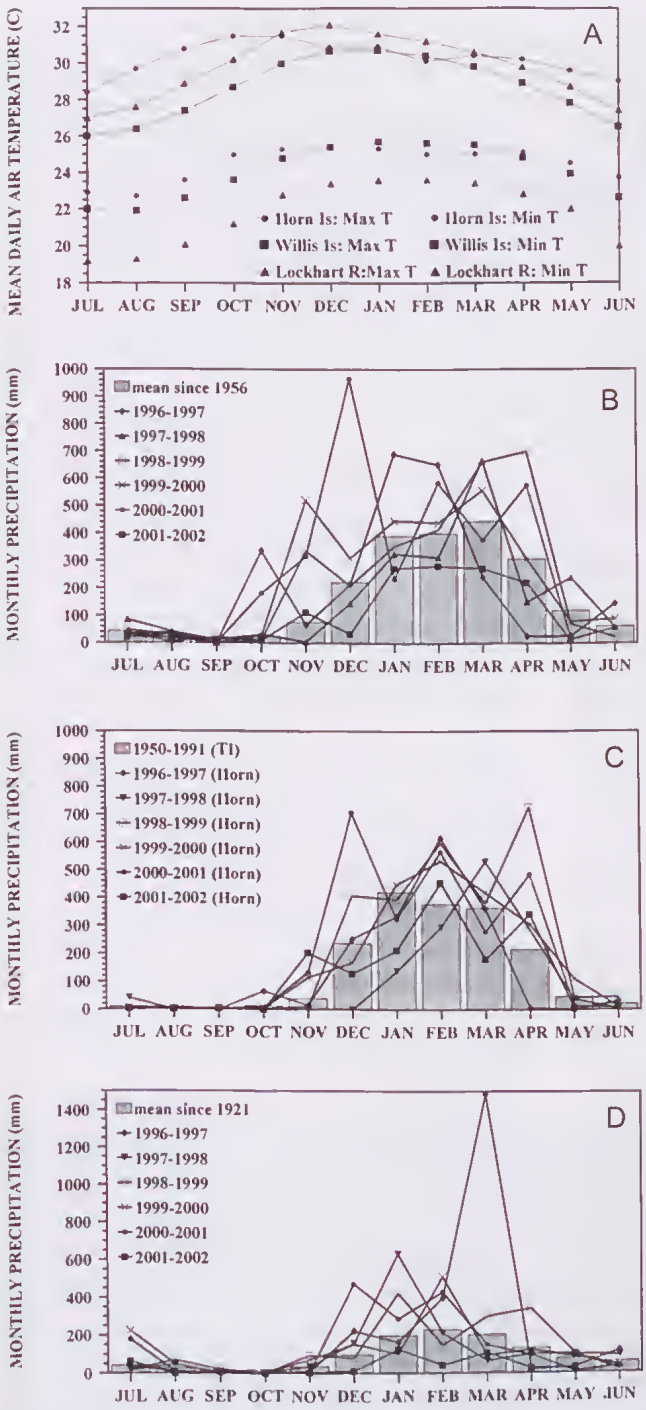

FIG. 7. North-western Coral Sea Regional climate data from Australian Bureau of Meteorology stations. A, monthly minimum and maximum air temperature data, Willis Island. B, monthly rainfall data from Lockhart River, NE Cape York Peninsula. C, monthly rainfall data from Horn Island and Thursday Island (TI), Torres Strait. D, monthly rainfall data from Willis Island.

and other visitors to the area, newspaper accounts of visits to the islands, and old photographs and documentaries. Together they contain a considerable body of knowledge, spanning 131 years of turtles at Raine Island and Moulter Cay. Also highlighted are some past misconceptions concerning marine turtle biology, including the belief that marine turtles could be systematically exploited on a grand scale.

HISTORICAL REVIEW. Raine Island was discovered by Thomas Raine on the HMS *Surry* in 1815 (de Salis, 1969). He did not land on the island and no reference was made to turtles.

Jukes (1847: 130-131) provided the first description of Raine Island and its natural history during the visit by HMS *Fly* on 29-30 July 1843. While the primary interest in the turtles was to provision the ship, Jukes provided some interpretation of the behaviour of the turtles at the island. They recorded a few turtle tracks on the beach, but did not capture any. Jukes was impressed by the large numbers of dead turtles and turtle bones on the island. He interpretation of the cause of their death was 'that when feeble, from sickness or age, the turtles have come here to die, and that those lying on their backs had died in a vain attempt to crawl up the broken bank into the interior of the island' (Jukes, 1847: 130). On 1 August 1843 he expressed a similar interpretation of why large numbers of turtles died at Moulter Cay (Jukes, 1847: 131).

HMS *Fly* and HMS *Bramble* returned during 29 May - mid September 1844 with a labour force of convicts to construct a navigation beacon on Raine Island (Jukes, 1847). The quarries dug during this construction work provided insights into the geology of the island and observations of fossil turtles and turtle eggs in considerable abundance (Jukes, 1847). Based on his observations of the fossil turtle eggs in nests, Jukes concluded that the rock forming the central elevated platform of Raine

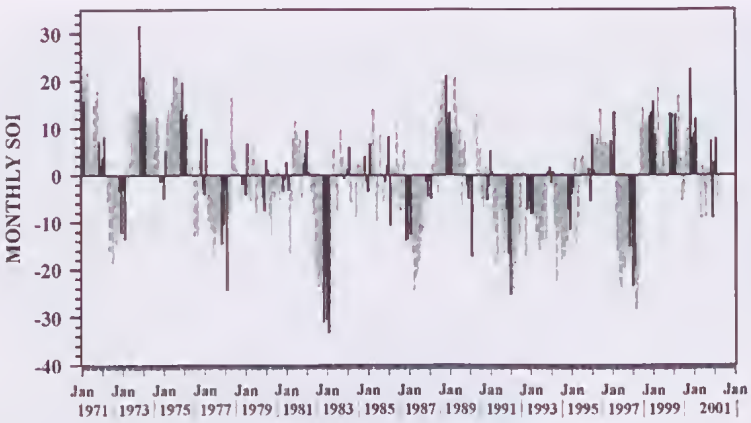

FIG. 8. Fluctuations in Southern Oscillation Index (SOI) over the 31 summers 1971 - 2001 (Bureau of Meteorology Australia, 2002). Summer SOI values (November - February) are shown in black.

Island had not been formed underwater and subsequently elevated.

MacGillivray (1846: 1474-1478), the naturalist on board HMS *Rattlesnake*, also visited Raine Island at this time and commented on the fossil turtle eggs in nests, citing them as evidence of the recent formation of this bed of sandstone 'only a few feet thick' where the rock for the tower was quarried. MacGillivray (1846) also made a number of original observations on the biology of the nesting turtles. All turtles visiting Raine Island and adjacent islands were '*green*' turtles which came to lay eggs, mostly at night. During June to August, single turtles came ashore at irregular intervals while the nesting density increased during September. He expressed surprise at the number of dead turtles on their backs which he interpreted as turtles that had fallen on their backs while endeavouring to climb the low rocky border of the island. He makes no reference to Dipterans associated with the turtle carcases, but notes the presence of 'several necrophagous Coleoptera'. Turtle bones were abundant enough on the island for him to note that 'noddies, *Anous stolidus*, used fragments of turtle shell and turtle bones among their nest building material'. While he wrote that hatchling turtles were 'preyed upon by various kinds of sea-fowls, from the frigate-bird down to the sooty tern', he only reported on one observation of a 'young turtle from the stomach of a tern which had swallowed it entire'.

An immature hawksbill turtle, *Eretmochelys imbricata*, was presumably collected during the 1844 visit by HMS *Fly*: British Museum specimen, register no. 46.7.27.6; immature with curved carapace length = 35.5cm; collected at Raine Island and presented by Lieut. Ince in July 1846 (A.F. Stimson in litt., 26 May 1977). This is the Boulenger (1889) specimen 'w'.

The crew of the *Heroine* went ashore on Raine Island on 28 January 1845 at daylight and 'obtained fourteen large turtles, each averaging four cwt.; also an immense number of eggs, and the crew killed birds out of number' (Mackenzie, 1845: 494).

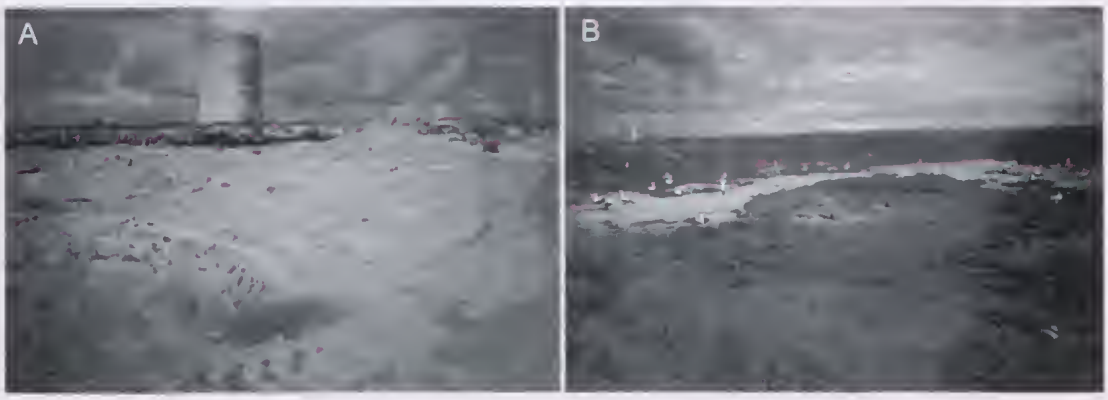

FIG. 9. Raine Island during early December 1999 showing: A, the elevated water table level on the southern beach platform; B, a perched water layer in the central depression (flooding at this level is not tidal).

Sweatman (in Allen & Corris, 1977) was a clerk on board HMS *Bramble* with a responsibility for keeping records of provisions for the ship throughout its voyages and, as a result, his diary provides many quantified details of the occurrence of turtles. Crew members from HMS *Bramble* were on Raine Island during 28 April - 4 May 1845 when they caught 14 turtles. One was a live turtle which had fallen into the well near the tower and been trapped there for some time. He describes nightly patrols of the island at 2 hourly intervals to locate the nesting turtles, the walking of the turtles on tethers in the shallows to move them around to the anchorage end of the island by day and the novelty of riding on the turtles back in the shallows. Sharks were reported to attack the turtles being walked on tethers. Sweatman also describes abundant remains of dead turtles on their backs along the cliff.

Sweatman (in Allen & Corris, 1977: 55), in commenting on the food shortage on board HMS *Bramble* as she returned to Port Jackson on 9 July 1845, noted that 'Had it not been for the turtle caught at Raine's It. and the fish caught on the reefs we would have been destitute for food 3 weeks before'.

Stoddart et al. (1981) reported that the HMS *Heroine* was again in the vicinity of Raine Island on 5 August 1846 but there is no recorded attempt to collect turtles. However, the date of this visit is probably incorrect because the *Heroine* was recorded sunk on 24 April 1846.

On 24 July 1850 the HMS *Enchantress* was wrecked on Raine Island Reef. The crew went ashore on Raine Island and was rescued on 25 July 1850 by the by HMS *Lady Margaret* (Lack, 1953). The ship HMS *Constant* was also wrecked on Raine Island Reef on 12 July 1858 (Loney, 1980). There were no records of turtles being encountered by the survivors of either of these wrecks.

Rattray (1869) visited Raine Island in 1860 on board HMS *Salamander* and interpreted the phosphatic limestone rock of Raine Island as 'a thin layer of guano deposited by the numerous turtle and flocks of terns, gannets, and other aquatic birds that, like the former, make this their headquarters and favourite breeding-place'. The authors are unaware of any other report that attributes guano formation to turtle nesting activity. Given that turtles do not defaecate while on the nesting beach, this interpretation is presumed to relate to the incorporation of decaying turtles into the substrate.

In 1860, HMS *Herald* visited Raine Island twice (Denham, 1861): in April when supplies were left on the island; and 19 September to check on the condition of the supplies. There was no reference in Denham's diary to turtles or any other aspect of the island from either visit.

In 1862, Raine Island was leased for guano mining but there appears to be no reference to turtles in respect to this (Crowther, 1939).

In about 1874 a beche-de-mer fishery camp was operating on Raine Island and staffed by 2 whites, 2 or 3 Chinese, several Kanakas and some aboriginals from the adjacent mainland (Ellis, 1936). The duration of this operation was not stated but Ellis implied that they harvested turtles from the island to provision the crew.

Moseley (1879), in reporting on the 31 August 1874 visit of HMS *Challenger* to Raine Island, commented on the death of large turtles on the island. He interpreted the death of many turtles at the base of one part of the cliff as being the result of turtles coming ashore to lay eggs. He believed that they were unable to turn around or go backwards and hence died at the foot of the small cliff.

During 1890-92, Raine Island was extensively mined for guano with approximately 110 persons resident on the island at times and turtles were taken for food (Ellis, 1936). The total harvest was not documented: one turtle was killed daily during the nesting season to feed the European staff (about 10 people); eggs were also occasionally eaten; but the consumption rate by the approximately 100 Chinese labourers was not recorded. Ellis, the manager of the mining operation, provided the first account of the massed nesting by green turtles at the island: 'The coral sand beaches of Raine Island were visited by incredible numbers of green turtles during the summer months, for the purpose of laying their eggs. In the height of the season it was difficult to find a few yards of beach free from their broad tracks made the previous night, when perhaps more than a thousand would have come up'. Ellis's description also includes an account of the nesting behaviour of the turtles that agrees well with the recent technical description of green turtle nesting behaviour by Bustard & Greenham (1969). He gives a clutch count of 'eighty to a hundred or more' and an incubation period of 'about six weeks'. He provides a vivid account of the co-operative digging of hatchlings to reach the beach surface, the resting of masses of hatchlings near the beach surface until after dark,

the synchronous emergence of hatchlings from a nest and their vigorous dash for the sea. Ellis makes no reference to birds as predators of hatchlings but gives the impression that sharks took large numbers of hatchlings as they sped across the reef flat. The sport of riding turtles over the reef flat is commented on, and support is given to De Rougemont's claims that people could ride turtles in the sea (Maslen, 1977). The large numbers of nesting turtles were regarded as a nuisance as they dug up paths and disturbed people's sleep when they threw sand against the sides of houses during the night. Ellis also described turtles entering the central depression and dying of heat exhaustion during the day.

W. MacGillivray, an ornithologist, made several trips to Raine Island and the adjacent area during 1910-1913. On 30 October 1910 he recorded 'great numbers' of turtles on the beach at Raine Island and in the adjacent shallows (MacGillivray, 1910). During his 9-15 July 1911 visit to Raine Island he made no reference to turtle nesting or to bird predation on turtle hatchlings (MacGillivray, 1914). However, during his 4-12 December 1913 visit he provides a description of Raine Island and Moulter Cay under high density green turtle nesting conditions (MacGillivray, 1917). In this account, the crew were described leaping from the boat onto turtles for rides as hundreds of turtles swam past the vessel and, after the party landed, riding turtles down the beach into the water. MacGillivray described himself as 'absorbingly interested in the wonderful bird-life' of the islands during the day and 'tormented at night by the nesting turtles, who would persist in trying to walk over or under our sleeping shelter'. This negativity towards the turtles was not evident in his graphic word picture of massed nesting at Moulter Cay: 'In the moonlight we noticed thousands of turtles climbing the sand-bank, their wet backs gleaming with phosphorescence as they leave the water'. The whole surface of Moulter Cay was described as 'ploughed up by the tracks and pits of the reptiles, and the air is redolent with the odour of the dead'. At Moulter Cay he also described the destruction by nesting turtles of bird eggs in a large crested tern, *Sterna bergii*, nesting colony. *S. bergii* and silver gulls, *Larus novaehollandiae*, were recorded scavenging on turtle eggs dug up by nesting turtle during the previous night at Raine Island. Rufous night-herons, *Nycticorax caledonicus*, were recorded as numerous on Raine Island and identified as predators of the hatchlings (MacGillivray, 1918a). In his summary of brown booby, *Sula leucogaster,* nesting, MacGillivray (1918b) again voiced negativity towards the turtles when he described Moulter Cay as 'a large turtle-infested sand-bank'.

On 7 September 1950, the Order in Council of 15 December 1932 under the Queensland Fisheries Act was repealed. The 1932 regulation had put in place a closed season for the harvest of green turtles and their eggs during the months of October and November south of 17°S. In its place, this 1950 Order in Council declared a year round closed season for green turtles and their eggs throughout all Queensland. This was the first conservation management measure applied to the north Queensland turtle populations.

Our discussions with several people, including D. Duffey in 1974 and J. Dagie in 1978, who had been crew members of trochus luggers that operated out of Torres Strait, indicated that trochus luggers travelling south for trochus gathering in Great Barrier Reef waters, regularly travelled via Raine Island. Here they took on live green turtles as deck cargo as food for the crews. Many of these islanders have left their names inscribed in the interior wall of the beacon as the only record of their visit to the island (Bairstow, 1983).

Vince Vlassoff (pers. comm., 2 April 1981) visited Raine Island during a summer turtle nesting period in February - March of 1956 (the same year that Cyclone Agnes impacted north Queensland). During one night, his party counted turtles in several hundred yards of beach and extrapolated for the entire beach. They estimated 10-12 thousand green turtles for the night. They rescued about 10 turtles per morning from on their backs at the base of the cliffs. It was estimated that they 'could smell dead turtles from about 2 miles (3km) out to sea' (Fig. 10). The well was about 4ft (~1.3m) deep but had been filling up with dead turtles (Fig. 10D). Photographs taken on this trip provide the opportunity for the first independent validation of the species identification of the nesting turtles at Raine Island. Up to this time, it appears that no specimen of a green turtle from Raine Island or Moulter Cay had been lodged in a Museum. During this trip Vlassoff was accompanied by an Italian film crew from the Astoria Film Society. They filmed for an Italian documentary titled *La Grand Barrier*. This documentary, if it still exists, would provide the oldest film record of the island

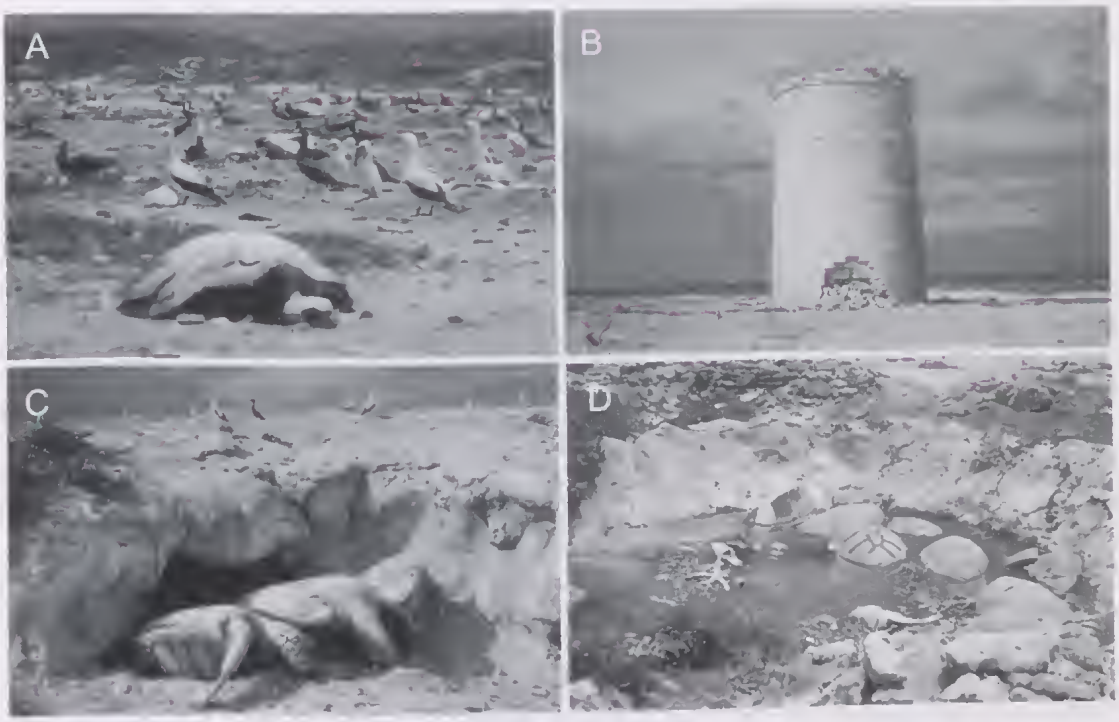

FIG. 10. Raine Island in February to March of either 1954 or 1956. Photographs by V. Vlassoff showing evidence of extremely high density turtle nesting for one or both of these breeding season. These are the oldest images located for Raine Island. A, numerous recently dead adult *Chelonia mydas* that had died from heat exhaustion within the central depression. B, the surface of the rock platform adjacent to the beacon was almost completely devoid of vegetation. C, a group of dead or dying adult female *Chelonia mydas* that had fallen over the cliff onto their backs. Note the relatively bare sand surface of the rock platform above. D, remains of 12 recently dead adult *Chelonia mydas* in the well at the western end of the central depression of the rock platform.

and its wildlife, including footage from a very high density turtle nesting season.

During 20-25 July 1957, Vince Vlassoff returned to Raine Island on his vessel, *Tropic Seas*, with a BBC Film Unit including producer David Attenborough (D. Attenborough, in litt. 4 April 1984; V. Vlassoff, pers. comm., 2 April 1981). The BBC documentary *Zoo Quest: The Birds of Paradise II. Raine Island* was filmed during this visit. This documentary provides a visual description of an island lush with grass cover across the rock platform. The images of dead turtles in the documentary were consistent with few turtles having died in the turtle breeding season some six months earlier. All except one carcass was a year or more old. There was low density turtle nesting during this winter visit with about twenty sets of tracks from nesting turtles counted in four nights. This documentary and photographs by D. Attenborough provide the first positive identification that the turtle species breeding at Raine Island in mid-year (winter) is *C. mydas*.

Changes in fisheries regulations in 1958 opened the way for commercial harvesting of turtles from the northern Great Barrier Reef. Records contained in the 1956-1958 Queensland Department of Harbours and Marine files indicate that the Cairns based Whittaker brothers (Snowy and Neil), of the fishing vessel *Trader Horn*, lobbied during 1956 and 1957 via their local member of parliament, G.W. Wallace MLA, to have permits issued to harvest turtles in north Queensland. They claimed that there were so many turtles nesting in areas of the Northern Great Barrier Reef that the turtles were unable to find places to deposit their eggs and consequently they dig out eggs previously laid by other turtles, and that on the following morning these are eaten by the birds. They further claimed that 'over a period of six to eight weeks, as many as 1,500 turtles visit Raine Island nightly' (B.W. Dick, in litt. 26 Feb. 1957, Brisbane). They suggested that the permit embrace the area from Olinda Entrance to No. 7 Bank, including Pandora (= Moulter Cay), Raine

Island, Ham Reef, Derry and Nos. 8 and 7 Sandbanks. Their concept of the biology of green turtles included the following ideas: turtle laying season extended from about November to March; less than 1% of the turtles hatched are males and therefore, unlike most other animals eaten by man, it was better that the females should be taken; it was appropriate to harvest the female turtle on the nesting beach as she headed back to the water because as long as the females lay once the turtles reproduce themselves; very few hatchlings ever live to become adults which weigh about 114kg; green turtles take only about four years to grow to adults (Anon, 1959a); there were so many green turtles in the area that they really needed thinning out; and the crew would save more than they killed, because they would take any hatchling that they found to the water and save them from death by birds (Anon, 1959b). Their political lobbying was successful, and on 4 September 1958, the Order in Council of 7 September 1950 under the Queensland Fisheries Act was repealed and a new Order in Council declared which restricted the year round closed season for harvesting green turtles to south of 15°S. The year round closed season for turtle egg harvest throughout Queensland was retained. This meant that turtles could be harvested without restriction in Queensland north of 15°S.

In addition to published material and correspondence, information regarding the Whittaker's turtle harvesting business was obtained from interviews in Cairns in August 1983 by CJL with Neil Whittaker himself and E. Gray who was a crew member of the *Trader Horn* for the first major turtle harvesting trip to Raine Island in January 1959. Neil and Snowy Whittaker's vessel for the turtle harvesting from Raine Island was the *Trader Horn*: displacement 70 tons, engine 115HP, overall length 72ft, beam 17ft, draft 7ft, wooden hull, built by Alf Hansen of Cairns (N. Whittaker, pers. comm.). She carried 7 dories and a crew of 12 (Anon, 1959a). According to Neil, the *Trader Horn* had a freezer capacity of about 50,000lb (22,700kg); most of the turtles were taken from Raine Island but some came from Moulter Cay; Moulter was hard to work when a swell was running; they had no problem capturing 100 turtles per night for slaughter on every trip; turtles were turned on the beach at night, killed and partly butchered on the beach next morning, loaded on a dory (Fig. 11A), transferred to the *Trader Horn* where the meat was washed on the deck and butchering completed (Fig. 11B); only meat (= muscle) was taken. According to E. Gray: the turtles were butchered at the island, at first by using an axe; the white crew did not like this job and were slow; the boat went to Thursday Island to employ extra native crew to slaughter the turtles; in the latter part of the first harvest many turtles were shot for butchering; and the meat was marketed through Cairns. Gray also observed that the green turtles that they harvested were nesting in sufficient numbers so that 'at times you could walk a long distance along the beach from turtle to turtle'; most nesting was at night and on the eastern half of the island. Gray did not go on the second trip in February 1959. According to G. E. Rowell (in litt. to Queensland Department of Harbours and Marine, 21 April 1959), once the refrigerated holds were filled with turtle meat, killing ceased and the *Trader Horn's* deck was loaded with live turtle for the return trip to Cairns (Fig. 11C). The live turtles from the first major catching trip were slaughtered at the Smith's Creek Wharf in Cairns. Rowles, as Harbour Master, advised Whittaker that this was not permitted. Whittaker took the live deck cargo turtles from the last trip out to Michelmas Reef where they were butchered and the meat returned to Cairns.

The Whittaker's turtle harvesting enterprise was initiated with a small unquantified harvest from an unstated origin from early in the nesting season in late 1958 (Anon, 1959b). Some of this turtle meat was used to promote sales to Meyer Emporium of Melbourne, Victoria, and to presumably supply the demands of local hotels. The first substantial harvest occurred during a two week trip to Raine Island in January 1959 (Anon, 1959b). The second major expedition to harvest turtles occurred during February 1959. The itinerary of *Trader Horn* for this February trip was: 14th Raine Island, 14-16 Pandora Cay (= Moulter Cay), 17-18 Murray Island Sandbank, 19-22 Pandora Cay, 22 Raine Island. Whittaker met a visiting ornithologist, Dr Warham, on Raine Island by chance and invited him to travel with them for the remainder of the trip (Warham, 1963). On this latter trip, 508 turtles were taken that yielded about 36,000 lb of turtle meat (Anon, 1959c). G. Rowell (in litt. to Qld Dept. of Harbours and Marine, 10 April 1959) provided a summary of the combined summer's turtle harvests by the Whittakers: 'Turtle fishing was commenced in early January, and discontinued during March. During that period approximately 1,200 turtles were taken which produced approximately 80,000 lbs of meat (about 60 to 70lbs of meat per turtle)'.

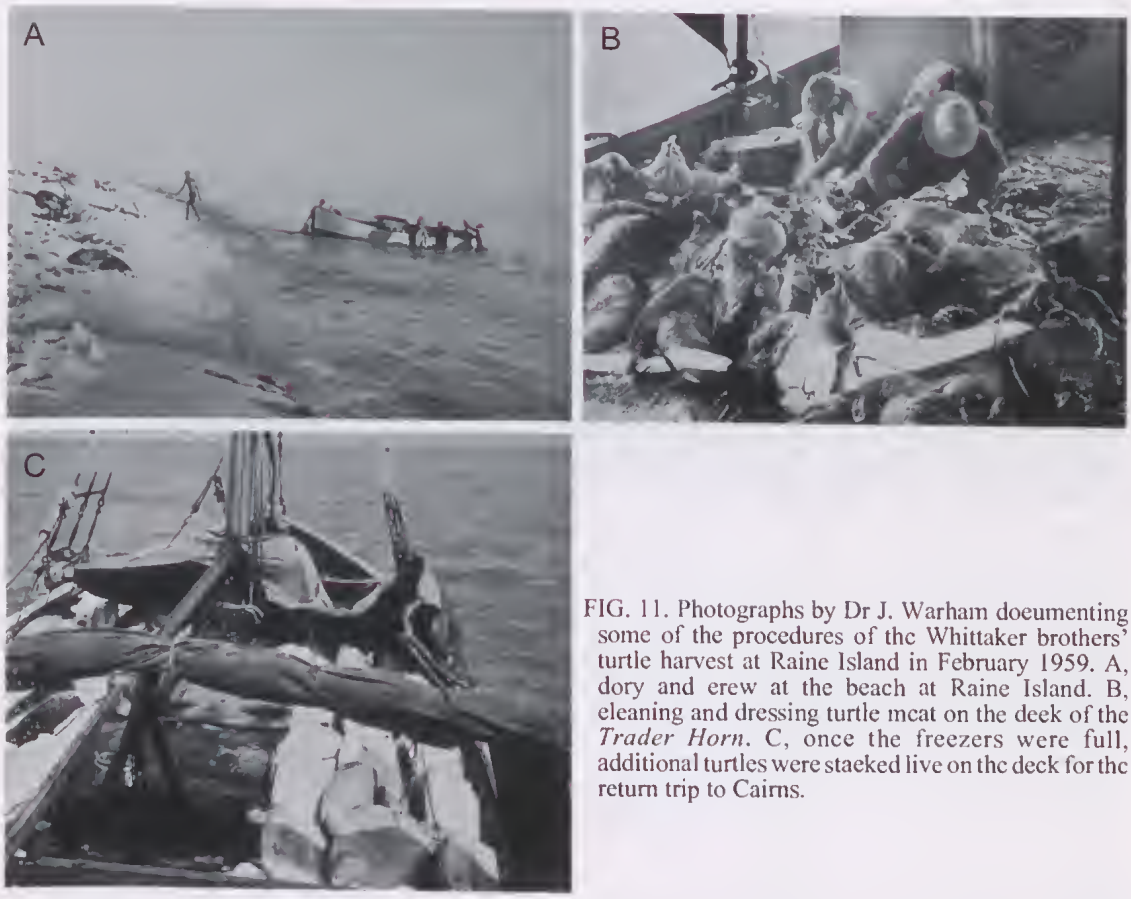

FIG. 11. Photographs by Dr J. Warham doeumenting some of the procedures of the Whittaker brothers' turtle harvest at Raine Island in February 1959. A, dory and erew at the beach at Raine Island. B, eleaning and dressing turtle meat on the deek of the *Trader Horn*. C, once the freezers were full, additional turtles were staeked live on the deck for the return trip to Cairns.

In preparation for the eommeneement of turtle harvesting from the Raine Island area, Mr T.A. Hiley was reported in the *Cairns Post* in Deeember 1958 diseussing a proposed amendment to the Fish Supply Management Aet that would remove turtles from the definition of fish under the Queensland Fisheries Aet. The purpose of this was to encourage development of the turtle meat industry north of Cooktown by allowing people engaged in the industry to operate outside the Fish Board and sell direet to the publie. This ehange in regulations did not oeeur.

Turtle meat was not novel to the Cairns community at this time. The Strand Hotel had been serving turtle steaks at the hotel for six or seven years (Anon, 1959b). The ehef, Mr. Leigh Kingston, aeknowledged that it was very popular with the southern tourists during the tourist season but the loeal people did not take to it too well at the beginning (Anon, 1959b). As part of the promotion for sale of turtle meat loeally, this hotel staged at least one eooking demonstration for the media and outlined styles of preparation of turtle meat meals prior to the first major eonsignment of turtle meat arriving in Cairns (Anon, 1959b). A loeal wholesaler in Cairns, Mr. M. Stoek, was organised to distribute the Whittakers' turtle meat at 3/- per lb (Anon, 1959b). Snowy Whittaker promoted it as reasonably prieed meat for the 'working man' (Anon, 1959b).

On 15 January 1959, L. Jorgensen, Manager of the Cairns Fish Board, announeed (Anon, 1959d) that under the Fish Supply Management Aet, beeause turtles were defined as fish under the Aet, it was illegal for the Whittakers to sell their turtle meat in Queensland to anyone exeept the Fish Board. They were however, entitled to sell their turtle meat direet to buyers outside Queensland. The Fish Board's eommission on the sale of turtle meat was 15%. Snowy Whittaker responded that 'the housewife would have to pay at least 4^{d} per lb more for it' (Anon, 1959e). Some of the turtle meat was passed immediately into the loeal Fish Board eoldrooms for loeal sales. By early February, turtle meat

FIG. 12. Label from a can of *Master Foods* turtle soup made from Raine Island *Chelonia mydas* harvested by the Whittaker brothers in January - February 1959. *Master Foods* continued to market turtle soup under this label for approximately another two decades even though their turtles did not originate from the Great Barrier Reef.

from Cairns at 4/6^{d} per lb was selling in Townsville in favour of more expensive beef (Anon, 1959f). The Whittakers canvassed markets interstate in Sydney and Melbourne with the assistance of the Queerah Meatworks providing storage of the majority of the meat without surcharge (Anon, 1959g; N. Whittaker, pers. comm.). Additional markets were also sought internationally in Singapore (Anon, 1959g) and New York (N. Whittaker, pers. comm.). As a result of a Cairns visit by Dr V. Lewis of the Sydney canning company of Lewis and Sons to inspect the Whittakers' catch (Anon, 1959h), most of the turtle meat was to be sold to Lewis and Sons at 1/9^{d} per lb (N. Whittaker, pers. comm.). This meat was processed at their Sydney cannery into turtle soup and marketed under the 'Masterfoods' label (Fig. 12) (N. Whittaker, pers. comm.). This association did not continue as expected because of financial issues (N. Whittaker, pers. comm.).

When sales of turtle meat did not increase as expected, a publicity campaign to counter the conservative eating habits of the north Queensland community provided recipes in the local news paper for cooking turtle meat, including fried turtle steak, crumbed steak, turtle hot pot, turtle rolls, turtle meat sate, turtle saute, turtle roast and curried turtle (Anon, 1959i; N. Whittaker, pers. comm.). Additionally, the Whittakers campaigned for the sale of turtle meat as an alternative to fish. This led to a debate as to whether turtle meat could be eaten by Roman Catholics on Fridays which resulted in Archbishop Duhig ruling that turtle was fish and therefore suitable for Roman Catholics to eat on Fridays (N. Whittaker, pers. comm.). This apparently initiated further discussion between the Fish Board and the Abattoir authority. Because turtles were fish under the Queensland Fisheries Act and under the Abattoir's Act, fish and meat could not be stored in the same coldroom, the turtle meat had to be removed from the meatwork's storage. As of 10 April 1959, of the original estimated harvest of 80,000lb of turtle meat, about 58,000lb remained in Cairns: 23,000lb of the 25,000lb received at the Fish Board, Cairns, remained unsold; and 35,000lb remained in other Cairns cold storage facilities although some of this had been purchased by a Sydney firm (G. Rowell, in litt. to Qld Dept. of Harbours and Marine). The turtle harvest from the Raine Island area did not continue beyond this one season because the Whittaker brothers considered that it was not profitable (N. Whittaker, pers. comm.).

One of the turtles brought back to Cairns by the Whittaker brothers was presented to the Cairns Ambulance Brigade. After preparation by a local taxidermist, this turtle was to be displayed in the first Cairns Ambulance Wildlife Exhibit at the Cairns show in 1959 in conjunction with 'Snakes Alive' (N. Whittaker, pers. comm.).

N. Whittaker (pers. comm.) provided some observations concerning turtle breeding in the 1950's: all the sandbanks of the northern Great

Barrier Reef carried a few nesting turtles, but none with numbers like Raine and Pandora (= Moulter); at Raine Island the turtles dug up lots of eggs while nesting; Raine Island was the only area with lots of frigatebirds and the frigates would prey on hatchling turtles by day off the beach and in the water; and Neil walked the beach one night after turning 100 turtles for killing and counted 'a thousand turtles in one walk of the island'.

Warham (1963) visited Raine Island on 7-14 and 22 February 1959. The crew of the fishing boat *Galeru* that delivered him to the island harvested a nesting turtle for food. Warham identified that many previously laid eggs were dug out by nesting turtles; landrails scavenged on these destroyed eggs; dead turtles were numerous; and some nesting turtles still ashore on the beach after daylight died from over heating. Warham (1961) provided a description of the topography and vegetation of the island, described green turtles as abundant, and identified the rufous night-heron, *Nycticorax caledonicus*, as a predator of turtle hatchlings. Warham (1961) also visited Moulter Cay during 14-16 and 19-22 February 1959. He described the island's topography and vegetation with a 'turtle churned level area surrounding a shrub covered centre. Crested terns, *Sterna bergii*, which were nesting and roosting on the island, patrolled the beaches at daylight and preyed on hatchling turtles on their way to the sea.

Both Neil Whittaker and E. Grey during their above interviews concerning the turtle harvest reported that some hawksbill turtles were seen nesting on Raine Island but not harvested.

Another turtle harvesting business started in Torres Strait at about the same time as the Whittaker brothers began their venture out of Cairns. This Torres Strait based enterprise started in a small way using Islander labour but the Department of Native Affairs disagreed with this and insisted that £15 per week be paid to the Islanders. This and unsuitable weather appear to have stopped the project (Harbour Master, Thursday Island, in litt. 9 June 1959).

There was at least one protest from the conservation lobby against this newly energised turtle harvesting industry. The Townsville and District Natural History Society wrote to the Queensland Government protesting against the slaughter of turtles for their meat (Anon, 1959j). John Warham, the ornithologist who was at Raine Island during one of the Whittaker's harvesting trips, while not critical of the Whittaker's operation, expressed the need for caution with regard to the number of licenees operating in the harvest if the turtle resource was not to be substantially reduced (Anon, 1959k).

Another proposal to create industry out of the Raine Island turtles in 1959 does not appear to have progressed to implementation. A Cairns-based mercantile firm, Cairns Coasters, had acquired samples of turtle bones from 'a vast natural grave yard ... on the outer reef six or seven hundred miles north of Cairns' to test for their phosphorus content (N. Whittaker, pers. comm.). The plan had been for their vessel. the *West Aussie*, to bring a shipload of bone back to Cairns every time it returned from Thursday Island.

HMAS *Gascoyne* visited Raine Island on 11 November 1961 and her crew carried out some repairs on the tower. There are no records referring to turtles from this visit.

Paul Watson (pers. comm. 18 June 1979) first visited Raine Island with V. Vlassoff in about late November 1965. The area of the island with the densest turtle nesting was at the tower end and south side. Most turtle nesting was by night. On one night Watson had been able to step or jump from turtle to turtle while Vlassoff walked 100 paces beside him. He reported that he subsequently visited Raine Island on a number of occasions in October - December in different years but never saw it again with turtles as thick as on his first visit.

On 18 July 1968 an Order in Council under the Queensland Fisheries Act declared an all year round closed season over all marine turtle species and their eggs through out all of Queensland. This marked the end of a 20yr window of opportunity for commercial harvesting of green turtles in the northern Great Barrier Reef.

In the early 1970s, Dr Robert Bustard, a Scottish herpetologist working out of Canberra who established the Applied Ecology Torres Strait Turtle farms, listed Raine Island as one of the important *C. mydas* rookeries for Queensland (Bustard, 1971) and identified Raine Island as one of the 15 most important green turtle nesting beaches worldwide (Bustard, 1972). In neither publication did he elaborate on how he arrived at these conclusions.

The James Cook University of North Queensland (JCUNQ) 1973 James Kirby Expedition conducted biological studies at Raine Island during 31 October - 4 November (Stoddart et. al. 1981). During this visit, Raine Island had a

measured high tide circumference of 2100m (1600m of sand and discontinuous narrow beach rock; 500m continuous beach rock). They recorded a nightly green turtle track count = 133.8 (SD = 17.8, range = 115-162, n = 4 nights). When corrected for turtles emerging across beach rock that did not result in tracks at the water line, their results indicated that about 200 nesting turtles were coming ashore nightly. Their mean curved carapace length = 109cm (SD = 5.29cm, range = 90-122cm, n = 124). At the time of this early nesting season visit, there was still a substantive *Lepturus* tussock grassland extending out from the cliff to the bare sand beach. In their effort to estimate the size of the total nesting population, they have assumed a 100% nightly nesting success and that the nesting habitat does not include that area of grassland below the cliff. Based on the unquantified observation that some animals 'differed markedly in degree of curvature of carapace', Stoddart et. al. (1981) postulated that some of the nesting turtles may have been flatback turtles, *N. depressus*. It appears that none of the observers had prior experience with the flatback turtle and no photographs were recorded of any of the presumed flatback turtles. We therefore reject this identification in light of prior and subsequent data. CJL examined the skull collected from the dried carcass of an adult sized *E. imbricata* found in central depression of Raine Island by J. Collins during this JCUNQ visit (Limpus, 1980a) and while not reported by Stoddart et. al. (1981), this skull remains the only conclusive evidence that occassional *E. imbricata* come ashore to nest on Raine Island.

Commenting on his first visit to Raine Island in late January 1974, Ben Cropp (pers. comm. 3 March 1975): expressed the opinion that the abundance of track each morning in early 1974 was of the same order of magnitude as he saw on his next trip to the island in February 1975 when he was accompanied by CJL, i.e. tracks from several hundred turtles per night.

Dr G. Goedon of the Queensland Fisheries Service (pers. comm. 1975) counted about 50 recent sets of tracks below the high tide level in one walk of Raine Island in early October 1975. Later in the same breeding season, Dr J. Kowarsky of Applied Ecology Pty Ltd recorded numerous sets of green turtle tracks on Raine Island from the night of 13 January 1976 (Kowarsky, 1978). These tracks were observed during an aerial survey and were not accurately countable. A Torres Strait Islander reportedly counting 160 tracks (? = 80 turtles) freshly made in one night on 29 January 1976 (J. Kowarsky, in litt. 3 March 1976). While Kowarsky was unsure of the accuracy of the count, it is clearly consistent with few turtles nesting on Raine Island that night.

HISTORIC SUMMARY. The authors are unaware of any written records or evidence at the island of use of Raine Island by indigenous people prior to its discovery by Europeans in 1815. However, it is highly likely that at least the inhabitants of Murray, Darnley and Stephen Islands of eastern Torres Strait, with their large dugout sail canoes would have visited these islands prior to European arrival. Similarly there is the possibility that aboriginals from the adjacent mainland may have also ventured out to Raine Island under favourable weather conditions, given that the island is visible from the top of some inshore islands (e.g. Sir Charles Hardy Islands) on a clear day. Since its discovery by Europeans, Raine Island has been inhabited for extended periods on three occasions: during the building of the beacon in 1844, by a beche-de-mer fishery crew in the 1870's and by guano miners for 3 yr from 1890. During the same period, neither Raine Island nor Moulter Cay have been continuously inhabited by indigenous peoples.

From the earliest records of these islands in 1843 until the present times, it is apparent that Raine Island has been a significant *C. mydas* rookery and that large numbers of nesting females may die on the island each year from natural causes.

Since European discovery of these islands, there was only sporadic low intensity harvest of the nesting *C. mydas* at the islands up until January 1959. During January - February 1959 there was a harvest of approximately 1,200 nesting *C. mydas* from Raine Island and Moulter Cay. This large scale harvesting of the nesting turtles was not repeated. Raine Island and Moulter Cay appears to be one of the least disturbed major *Chelonia mydas* rookery regions of the World, having escaped the ravages of intensive turtle harvesting associated with European colonial expansion into tropical seas (Parsons, 1962; Hirth, 1997).

BREEDING DISTRIBUTION IN THE NORTHERN GREAT BARRIER REEF

BREEDING SPECIES. The distribution and abundance of nesting by marine turtles in the

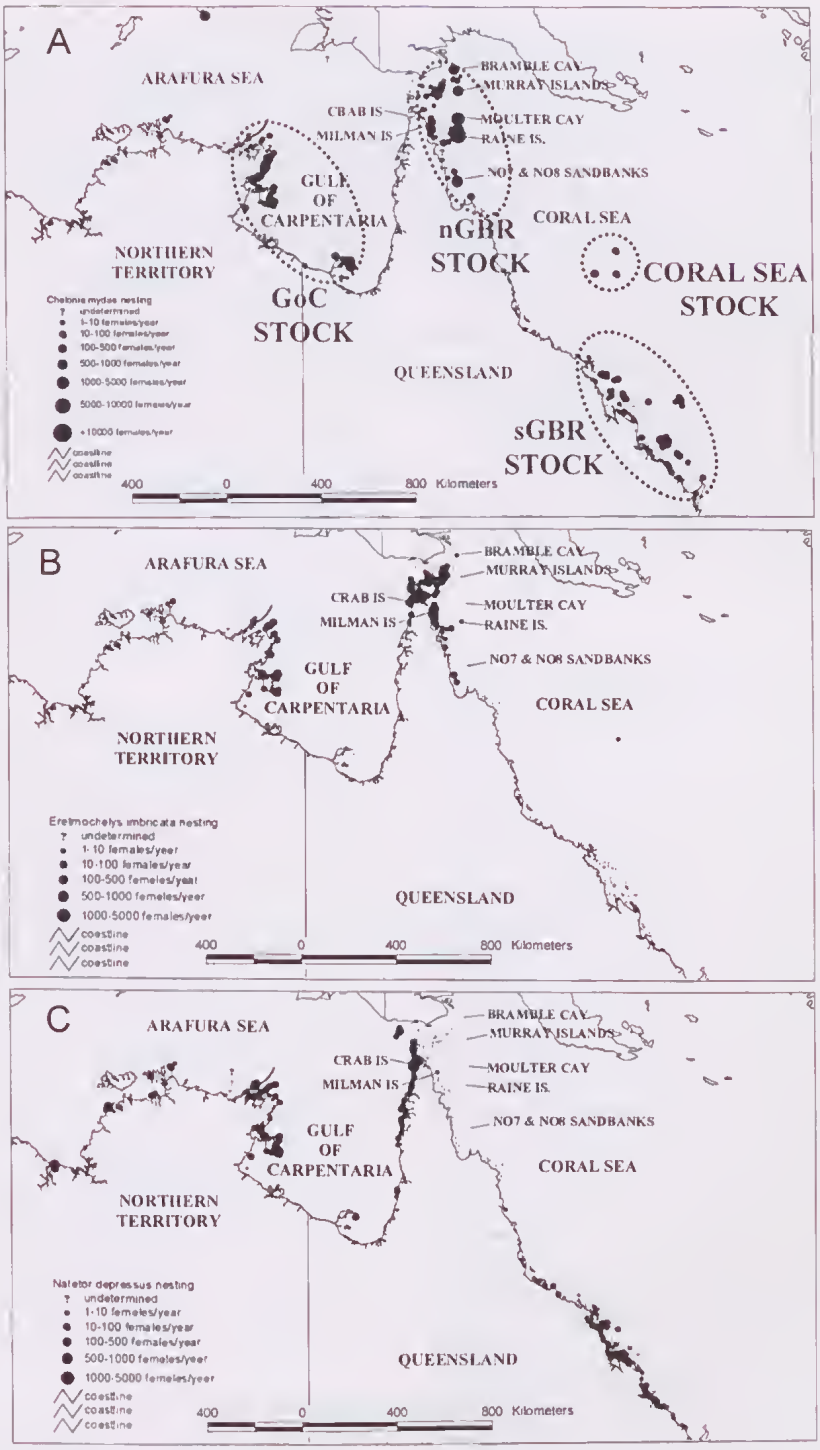

FIG. 13. Maps summarising the distribution and abundance of marine turtle nesting in Queensland. These maps were generated from the QPWS marine turtle nesting database. A, *Chelonia mydas*, green turtle. The groupings of rookeries that represent each of the four genetically separated stocks that breed in northeastern Australia are identified. B, *Eretmochelys imbricata*, hawksbill turtle. C, *Natator depressus*, flatback turtle.

northern GBR and Torres Straight region was undertaken throughout this study by teams landing on beaches and counting turtles or tracks for each species on a nightly basis (Tables 3-6). During the late 1990s, additional data on the temporal and spatial distribution of marine turtle breeding in Queensland was recorded during dedicated aerial survey of nesting beaches (Limpus et al., 2000). Detailed studies of turtle nesting biology from the region have also been published for Bramble Cay (Limpus et al., 2001), Milman Island (Dobbs et al., 1999) and a northern GBR-Torres Strait survey of *E. imbricata* nesting (Miller, et al., 1995). These data have been incorporated into the QPWS Marine Turtle Atlas. This is a relational database that summarises the breeding season, location and estimated size of the annual breeding population by species for marine turtles in Queensland. Analyses of these data have been output as summary maps using GIS software (Fig. 13).

Green turtle, *Chelonia mydas*. There are three concentrations of *C. mydas* rookeries in Queensland: southern GBR; northern GBR and adjacent Torres Strait and southern Gulf of Carpentaria with a fourth adjacent cluster of rookeries on the Coral Sea Platform (Fig. 13A). These data, including the results of the on ground surveys of turtle nesting throughout the northern GBR and Torres Strait region (Tables 3-6), show that *C. mydas* breeding is concentrated onto the cays of the outer barrier reef from Bramble Cay to Princess Charlotte Bay. The main concentration within this outer barrier reef nesting zone occurs on Raine Island (Table 3) and Moulter Cay (Table 4) with subsidiary concentrations on Bramble Cay, Murray Islands (Fig. 13A), No.8 Sandbank and No.7 Sandbank (Table 5). *C. mydas* breeds less frequently on the inner shelf sand cays, continental islands and adjacent mainland (Table 6).

Since 1974 hundreds of thousands of nesting and recently dead adult *C. mydas* and their hatchlings have been observed at Raine Island, Moulter Cay, MacLennan Cay and No.8 and No.7 Sandbanks. A total of 34,361 tagged female *C. mydas* were processed while nesting at Raine Island and 3,015 at the other outer barrier reef islands (Tables 7-9). During the 32 trips on which tagging and census studies were conducted by QPWS and/or Applied Ecology, no adult turtle, turtle track or hatchling of a species other than *C. mydas* was recorded from Raine Island, Moulter Cay, Maclennan Cay, No.8 Sandbank or No.7 Sandbank.

Hawksbill turtle, *Eretmochelys imbricata*. There is one concentration of *E. imbricata* rookeries in Queensland: on coral cays of the inner shelf of the northern GBR from the Piper Islands north to the sand islands and continental islands of central and western Torres Strait (Fig. 13B; Table 10). Low density to sporadic nesting occurs south of the Piper Islands to Princess Charlotte Bay.

British Museum specimen, registration no. 46.7.27.6 is an immature specimen with CCL = 35.5cm collected at Raine Island (A.F. Stimson, in litt., 26 May, 1977) which was presented to the museum by Lieut. Ince in July 1846. This is the Boulenger (1889) specimen 'w'. It was on the basis of this specimen that Stoddard et al. (1981) associated the species with Raine Island. However, the latter study failed to recognise that the turtle was an immature, presumably having been caught on the surrounding reef at the time of the construction of the beacon in 1844. Immature to adult-sized *E. imbricata* were occasionally seen on Raine Island Reef during the present study.

J. Collins (JCUNQ) collected the skull from an adult *E. imbricata* carcass within the central depression of Raine Island in November 1973 (Limpus, 1980a). As only nesting female turtles venture this far inland, this must be accepted as a breeding record for the species from Raine Island. During the January-February 1959 harvest of *C. mydas* from Raine Island by the crew of the *Trader Horn*, 'hawksbill turtles' as well as the abundant green turtles were identified as being ashore nesting (E. Gray, pers. comm., 1983; N. Whittaker, pers. comm., 1983). *E. imbricata* breeding at Raine Island and adjacent outer barrier cays during the present study period may have been unrecorded because very little census work has been conducted during January-March which is the peak of the region's *E. imbricata* nesting season (Dobbs et al., 1999). At Bramble Cay, *E. imbricata* nests at very low density mostly during the January-March period (D. Carter, pers. comm.; C.J. Parmenter, unpubl. data). *E. imbricata* breeds at very low density on Raine Island and probably also on the adjacent outer barrier reef cays.

Flatback turtle, *Natator depressus*. There are three concentrations of *N. depressus* rookeries in Queensland: on continental islands and mainland beaches of the central east coast from Bundaberg to Townsville; sand islands and continental islands of western Torres Strait and the mainland

TABLE 3. List of study trips to Raine Island and other islands of the northern Great Barrier Reef: November 1974 - December 2001, summarising the nightly counts of breeding female turtles and their associated mortality while ashore nesting on the islands. The nightly count of turtles is listed as the tally count or in parenthesis as a tagging census count. The mean nightly count was calculated on half monthly sampling intervals. Nightly mortality includes those turtles found alive but which would have died if left unaided and which resulted from that night's nesting attempt. Accumulated dead turtles were counted at the arrival of the study team for a census period. Only *Chelonia mydas* was recorded. # denotes that the count may include more than one night's nestings. tr = tracks. Key to notes: 1 = JCUNQ, A. Birtles; 2 = C. Limpus & B. Cropp; 3 = G. Goedon (pers. comm.); 4 = Kowarsky, 1978; 5 = QPWS; 6 = B. Cropp (pers. comm.); 7 = QPWS & AE; 8 = QPWS aerial survey; 9 = AIMS, D. Williams; 10 = QPWS/RIC; 11 = D. Williams; 12 = QPWS & GBRMPA; 13 = GBRMPA, J. O'Dyer; 14 = Operation Raleigh; 15 = A. Fleay (in litt.).

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
29/11/74	11565		281	11565	-	1	1
28/2/75	427 tr		>588	447 tr	-	4	2
1/3/75	517 tr						
2//3/75	408 tr						
3//3/75	435 tr						
22/10/75	~50 tr						3
29/1/76	~80 tr						4
2/12/76	-			872	-	2	5
3/12/76	-						
4/12/76	898						
5/12/76	-						
6/12/76	845						
Early/11/77	~40-50						6
3/12/77	(23)	0	0	(32)	-	5	7
4/12/77	(23)	0					
5/12/77	(19)	0					
6/12/77	(41)	1					
7/12/77	(53)	-					
1/12/78	(148)	0	1	(243)	-	5	7
2/12/78	(204)	0					
3/12/78	(240)	1					
4/12/78	(327)	1					
5/12/78	(295)	-					
29/10/79	-	0	18	416	-	2	5
30/10/79	381	0					
31/10/79	451	1					
1/11/79	410	0		427	-	2	
2/11/79	-	0					
3/11/79	-	0					
4/11/79	444	0					
5/11/79	-	0					
6/11/79	-	0					
7/11/79	-	1					
8/11/79	-	1					
9/11/79	-	0					
13/12/79	1211	0	72	1347	-	2	5
14/12/79	1482	3					
8/4/80	1-2 tr						8

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
9-23/6/80	-			0-1	-	14	5
8/12/80	71 (83)	0	0	59	17.5	5	5
9/12/80	68 (81)						
10/12/80	58						
11/12/80	69						
12/12/80	29 (80)						
28/2/81		-	-	(24)	12.7	7	9
1/3/81	(3)						
2/3/81	-	-					
3/3/81	(26)	-					
4/3/81	(36)	-					
5/3/81	(27)	-					
6/3/81	(36)	-					
7/3/81	(30)	-					
8/3/81	-	-					
9/3/81	(10)	-					
7/6/81	0	0	-	(0.4)	0.5	9	10
8/6/81	0	0					
9/6/81	0	0					
10/6/81	(1)	0					
11/6/81	(1)	0					
12/6/81	0	0					
13/6/81	(1)	0					
14/6/81	(1)	0					
15/6/81	0	0					
16/6/81	(1)	0		(0.3)	-	3	
17/6/81	0	0					
18/6/81	0	0					
12/11/81	1019	0	6	1009	-	3	10
13/11/81		0					
14/11/81	1103	2					
15/11/81	906	0					
16/11/81	955	5		2038	446.7	13	
17/11/81		0					
18/11/81	1722	1					
19/11/81	2074	4					
20/11/81	1943	5					

TABLE 3 (*Cont.*)

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
21/11/81	1986	0					
22/11/81	1954	6					
23/11/81	2565	2					
24/11/81	2369	3					
25/11/81	2307	2					
26/11/81	1542	9					
27/11/81	2263	7					
28/11/81	2212	6					
29/11/81		15					
3011/81	2599	10					
1/12/81	2757	6		2094	665.3	12	
2/12/81	2345	13					
3/12/81	1738	15					
4/12/81	1287	8					
5/12/81	1445	2					
6/12/81		2					
7/12/81	1394	2					
8/12/81	1832	2					
9/12/81	1795	8					
10/12/81	2654	5					
11/12/81	1817	8					
12/12/81	2599	8					
13/12/81	3463	8					
21/2/82	350			350		1	11
13/7/82	0	0	189	(0.3)	-	3	10
14/7/82	0	0					
15/7/82	(1)	0					
16/7/82	0	0		(0.5)	0.8	14	
17/7/82	(1)	0					
18/7/82	0	0					
19/7/82	(1)	0					
20/7/82	0	0					
21/7/82	(1)	0					
22/7/82	(2)	0					
23/7/82	(2)	0					
24/7/82	0	0					
25/7/82	0	0					
26/7/82	0	0					
27/7/82	0	0					
28/7/82	0	0					
29/7/82	0	0					
13/11/82	460	0	6	492	-	3	10
14/11/82	525	0					
15/11/82	490	0					
16/11/82	452	1		718	183.4	13	
17/11/82	470	1					
18/11/82	553	0					
19/11/82	670	0					

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
20/11/82	639	1					
21/11/82	716	0					
22/11/82	674	0					
23/11/82	670	1					
24/11/82	822	0					
25/11/82	854	0					
26/11/82	760	0					
27/11/82		0					
28/11/82		0					
29/11/82	1095	1					
30/11/82	959	0					
1/12/82	1000	2		925	112.5	6	
2/12/82		0					
3/12/82	878	0					
4/12/82	810	0					
5/12/82	809	1					
6/12/82	960	2					
7/12/82	1091	2					
8/12/82		2					
25/4/83	2 tr	0	82	3.2 tr	-	5	10
26/4/83	2 tr	0					
27/4/83	8 tr	0					
28/4/83	3 tr	0					
29/4/83	1 tr	0					
15/11/83	Several hundred tracks seen from air						12
3/4/84	8	0	92	9	4.2	13	10
4/4/84	9	0					
5/4/84	6	0					
6/4/84	11	0					
7/4/84	5	0					
8/4/84	3	0					
9/4/84	15	0					
10/4/84	17	0					
11/4/84	8	0					
12/4/84	7	0					
13/4/84	7	0					
14/4/84	6	0					
15/4/84	14	0					
16/4/84	3	0		5	1.9	9	
17/4/84	5	0					
18/4/84	5	0					
19/4/84	4	0					
20/4/84	2	0					
21/4/84	3	0					
22/4/84	7	0					
23/4/84	5	0					
24/4/84	8	0					
25/4/84		0					

TABLE 3 (*cont.*)

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
1/9/84	7 tr			7 tr	-	1	13
21/1184	7739	24	256	6376	-	5	10
22/1184		2					
23/1184	6459	14					
24/1184		15					
25/1184	7074	1					
26/1184		23					
27/1184	5428	33					
28/1184		19					
29/1184	5179	11					
30/1184		12					
1/12/84	7867	8		6493	1683	8	
2/12/84		23					
3/12/84	9301	22					
4/12/84		17					
5/12/84	7070	12					
6/12/84		29					
7/12/84	7099	19					
8/12/84		31					
9/12/84	5633	35					
10/12/84		21					
11/12/84	5764	11					
12/12/84		47					
13/12/84	5295	26					
14/12/84		29					
15/12/84	3916	34					
16/12/84		40		8873	2429	5	
17/12/84	5102	52					
18/12/84		52					
19/12/84	9776	44					
20/12/84	11467	25					
21/12/84	9960						
22/12/84							
23/12/84	8059						
24/11/85			4				10
25/11/85	119	0		196	-	3	
26/11/85		0					
27/11/85	308	0					
28/11/85		0					
29/11/85	162, 202 tr	0					
30/11/85		0					
1/12/85	214	0		227	38	6	
2/12/85		0					
3/12/85	205	0					
4/12/85		0					
5/12/85		0					
6/12/85	227	0					

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
7/12/85		0					
8/12/85	295	0					
9/12/85		1					
10/12/85	236	0					
11/12/84	5764	11					
12/12/84		47					
13/12/84	5295	26					
14/12/84		29					
15/12/84	3916	34					
16/12/84		40		8873	2175	5	
17/12/84	5102	52					
18/12/84		52					
19/12/84	9776	44					
20/12/84	11467	25					
21/12/84	9960						
22/12/84							
23/12/84	8059						
24/11/85			4				10
25/11/85	119	0		196	-	3	
26/11/85		0					
27/11/85	308	0					
28/11/85		0					
29/11/85	162, 202 tr	0					
30/11/85		0					
1/12/85	214	0		227	38	6	
2/12/85		0					
3/12/85	205	0					
4/12/85		0					
5/12/85		0					
6/12/85	227	0					
7/12/85		0					
8/12/85	295	0					
9/12/85		1					
10/12/85	236	0					
11/12/85		0					
12/12/85		0					
13/12/85	183, 323 tr	1					
14/12/85		0					
15/12/85		0					
16/12/85	105, 264 tr	1		151	-	3	
17/12/85		2					
18/12/85	142	0					
19/12/85	205	0					
20/12/85		0					

TABLE 3 (*cont.*)

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
17/10/86	137			130	-	2	14
18/10/86	123						
13/11/86	1439	0		1549	-	3	
14/11/86	1705	0					
15/11/86	1503	0					
16/11/86	1284	0		3145	-	5	
23/11/86	3142	11	90				10
24/11/86							
25/11/86	3208	23#					
26/11/86		7					
27/11/86	3525	7					
28/11/86		7					
29/11/86	4565	8					
30/11/86		8					
1/12/86	4696	8		3957	686	8	
2/12/86		13					
3/12/86	4547	6					
4/12/86		9					
5/12/86	3991	8					
6/12/86		9					
7/12/86	4838	11					
8/12/86		18					
9/12/86	3648	12					
10/12/86		7					
11/12/86	3643	6					
12/12/86		12					
13/12/86		12					
14/12/86	3382	22					
15/12/86	2910	-					
29/11/87		10	158				10
30/11/87	3296	10		3296		1	
1/12/87	2312	9		4099	-	4	
2/12/87		19					
3/12/87	4489	16					
4/12/87	4585	14					
5/12/87	5011						
29/11/88		1	52				10
30/11/88		2					
1/12/88	516	1		731	-	4	
2/12/88		1					
3/12/88		1					
4/12/88	1088	2					
5/12/88	671	0					
6/12/88		2					
7/12/88	647	0					
28/11/89		24	177				5
29/1189	5919	15		5919	-	1	
30/1189		16					

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
1/12/89		16		6144	-	3	
2/12/89		18					
3/12/89		19					
4/12/89		14					
5/12/89	5991	14					
6/12/89	5925	14					
7/12/89	6516	14					
29/11/91	2289	20	-	3571	3	6	10
30/11/91	-	6					
1/12/91	3360	8					
2/12/91	-	4					
3/12/91	3483	8					
4/12/91	-	13					
5/12/91	3492	16					
6/12/91	-	6					
7/12/91	3741	33					
8/12/91	-	36					
9/12/91	5062	20					
10/12/91	-	6					
29/11/92	850	3	-	1323	458	6	10
30/11/92	-	3					
1/12/92	874	12					
2/12/92	-	8					
3/12/92	1048	8					
4/12/92	-	7					
5/12/92	1591	6					
6/12/92	-	5					
7/12/92	1936	8					
8/12/92	-	8					
9/12/92	1638	5					
10/12/92	-	8					
29/11/93	9245	11	-	8593	585	6	10
30/11/93	-	33					
1/12/93	9012	27					
2/12/93	-	11					
3/12/93	7596	19					
4/12/93	-	0					
5/12/93	8384	10					
6/12/93	-	20					
7/12/93	8478	5					
8/12/93	-	8					
9/12/93	8841	20					
10/12/93	-	22					
30/11/94	-	0	-				
1/12/94	586	0		645	-	5	10
2/12/94	-	0					
3/12/94	836	0					

TABLE 3 (*Cont.*)

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
4/12/94	-	1					
5/12/94	729	1					
6/12/94	-	1					
7/12//94	404	0					
8/12/94	-	0					
9/12/94	671	0					
5/12/95	4653	5	191	4648	-	5	10
6/12/95	-	8					
7/12/95	4627	9					
8/12/95	5765	15					
9/12/95	4044	14					
10/12/95	-	0					
11/12/95	4150	4					
12/12/95	-	21					
13/12/95	-	6					
30/11/96	11755	67	150	12100	1421	7	10
1/12/96	-	51					
2/12/96	-	52					
3/12/96	11454	75					
4/12/96	11422	29					
5/12/96	10677	58					
6/12/96	-	65					
7/12/96	11209	42					
8/12/96	13667	62					
9/12/96	14519	26					
29/11/97	3184	11	186	4065	905	7	10
30/11/97	3279	6					
1/12/97	3881	4					
2/12/97	3292	10					
3/12/97	4312	10					
4/12/97	-	14					
5/12/97	5284	7					
6/12/97	5223	5					
28/11/98	110	1	35	472	245	7	10
29/11/98	300	0					
30/11/98	-	2					
01/12/98	762	0					
2/12/98	707	1					
3/12/98	-	0					

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
4/12/98	567	0					
5/12/98	583	0					
6/12/98	-	1					
7/12/98	-	0					
8/12/98	-	0					
9/12/98	273	0					
28/11/99	5806	41	213	5617	-	3	10
29/11/99	5834	18					
30/11/99	5212	13					
1/12/99	-	9		7079	776	8	
2/12/99	7010	14					
3/12/99	-	20					
4/12/99	6282	17					
5/12/99	6848	25					
6/12/99	6745	36					
7/12/99	8101	25					
8/12/99	-	35					
9/12/99	6301	24					
10/12/99	8408	32					
11/12/99	7077	41					
30/11/00	114	1	0	114	-	1	10
1/12/00	82	0		131	31	7	
2/12/00	-	0					
3/12/00	136	0					
4/12/00	136	0					
5/12/00	-	0					
6/12/00	107	0					
7/12/00	171	0					
8/12/00	165	1					
9/12/00	122	0					
1/12/01	4539	20	71	3601	1401	8	10
2/12/01	3194	5					
3/12/01	2462	6					
4/12/01	-	10					
5/12/01	1923	0					
6/12/01	2675	2					
7/12/01	3072	21					
8/12/01	4988	15					
9/12/01	-	15					
10/12/01	5952	4					

coast of north-western Cape York Peninsula and the Wellesley Island of the southeastern Gulf of Carpentaria (Fig. 13C). The on-ground surveys of turtle nesting throughout the northern GBR, recorded only sparse *N. depressus* nesting (Miller et al., 1995; Dobbs et al., 1999) (Table 6).

Stoddart et al. (1981) suggested the possibility that *N.* (=*Chelonia*) *depressus* nested at Raine Island. Their description of the turtles in question is not consistent with that of adult *N. depressus* but fits well within the normal variation in carapace shape of *C. mydas*. In view of the lack of

supporting evidence for the presence of *N. depressus* at Raine Island, the species should not be considered part of the nesting community of Raine Island or the adjacent outer barrier cays.

Loggerhead turtle, *Caretta caretta*. *C. caretta* has not been recorded breeding in the far northern GBR. An unsuccessful nesting attempt by the species was recorded from Lizard Island prior to this survey (Limpus 1982). This remains the only eastern Australian breeding record for the species from north of Townsville.

Misidentified species. The Leatherback turtle, *Dermochelys coriacea* was recorded ashore at Moulter Cay and Raine Island on 8th and 16 November 1986 among the nesting *C. mydas* (Anon., 1986). The turtles were not described in detail, nor were they measured or photographed. Given that the recorders were naive with respect to marine turtle identification, that during the same breeding season the species was not encountered by experienced observers at these islands, and that the species has not been recorded by any other observers at these islands at any other time, *D. coriacea* will not be considered as part of the marine turtle fauna of the Raine Island area. No records of *D. coriacea* breeding were obtained during the surveys of turtle breeding throughout the remainder of the northern GBR and Torres Strait (Miller et al., 1995; Limpus et al., 2000) (Tables 5-6).

CHELONIA MYDAS BREEDING SEASON. Ellis (1936) in summarising his stay on Raine Island from late 1890 to 1892, identified pedominantly summer nesting by green turtles. The next longest reported habitation of the island was during the construction of the beacon from 29 May until mid September 1844 when MacGillivray (1846) reported only irregular isolated nestings by green turtles with numbers increasing in September. All remaining reports are from trips of about a month or less in duration and at irregular intervals. The nightly density of turtle nesting recorded on all visits to Raine Island and other islands of the northern GBR since November 1974 are summarised in Tables 3-5.

The historical data and that of Tables 3-4 have been combined to produce a summary of the breeding season by months for Raine Island and Moulter Cay (Table 11). While there are marked differences in nesting density from year to year, the general pattern is for sporadic nesting to occur during the dry season (May - August) and breeding turtle numbers to increase from

TABLE 4. Moulter Cay. Only *Chelonia mydas* was recorded nesting at Moulter Cay. See Table 3 for symbols and codes.

Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Mean nightly female count			Notes
				Mean	SD	n	
5/3/75	244 tr	0	142	244 tr	-	1	2
7/12/76	(430+)		7				5
2/12/77	13 tr	0	0	13 tr	-	1	7
24/6/80	0	0	28				10
19/6/81	0						10
30/7/82	0	0					10
10/12/82	402 tr		3	402 tr	-	1	10
14/12/85	148	0	3	157	-	2	10
15/12/85	166	0					
17/10/86	58			76	40	7	14
18/10/86	55						
21/10/86	61						
22/10/86	88						
23/10/86	74						
27/10/86	38						
28/10/86	160						
6/11/86	210			357	108	3	
7/11/86	407						
8/11/86	458						
16/11/86	747			747	-	1	
14/12/86	1669			1807	-	2	10
15/12/86	1945						
4/12/88	627	3	17	627	-	1	10
13/12/92	180 tr	0	0	180 tr	-	1	10
7/12/93	5057	-		5057	-	1	10
7/12/95	2495	0	39	2495	-	1	10
27/11/96	4043	-	-	4043	-	1	10
7/12/97	1671	6	45	1624	-	2	10
8/12/97	1577	2					
10/12/98	-	0	21			2	10
11/12/98	-	0					
12/12/99	3665	31	60	3665	-	1	10
10/12/00	67	1		67	-	1	10
10/12/01	1881	-	42	2022	-	2	10
11/12/01	2163	3					

September and reach a maximum in December and January. Numbers decrease again into the dry season. This also is the pattern for *C. mydas* nesting elsewhere in the northern GBR: at Bramble Cay to the north (Limpus et al., 2001) and at No.7 and No.8 Sandbanks to the south (Table 5). In the southern GBR, *C. mydas* nesting is seasonal, being confined to the mid summer (October - April) period (Bustard, 1972; Limpus,

TABLE 5. Other outer Barrier Reef coral cays of the far northern Great Barrier Reef. Only *Chelonia mydas* was recorded at these islands. See Table 3 for symbols and codes.

Rookery	Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Notes
Bramble Cay	3/1/87	340 tr			5
	4/1/87	290 tr			
	16/1/89	(272)	0	0	5
	17/1/89	(140)	0		
Maclennan Cay	30/11/78	(4)	0	0	7
	25/6/80	0	0	0	10
	19/6/81	0	0		10
	30/7/82	0	0	0	10
	4/12/88	(8)	0	0	10
No.8 Sandbank	28/11/76	~65 tr	0	0	5
	29/11/76	25 tr	0		
	11/12/79	114 tr	0	0	5
	5/6/80	0	0	1	10
	25/6/81	0	0		10
	10/7/82	0	0		10
	11/12/82	(118)			10
	17/12/86	(102)	0		10
	28/11/87	193 tr	0		10
	27/11/88	(30)	0	0	10
	24/11/89	234	0	0	5
	27/11/91	79 tr	0	0	10
	27/11/92	63 tr	0	0	10
	3/12/95	121 tr	0	0	10
	11/12/96	-	0	2	10
	10/12/97	119	0	2	10
No.7 Sandbank	28/11/76	~60 tr	0	0	5
	11/12/79	108# tr	0	4	5
	4/6/80	0	0	3	10
No.7 Sandbank	17/11/81	205# tr	0	0	10
	17/12/86	(79)	0		10
	28/11/87	94 tr	0	0	10
	27/11/88	(26)	0	0	10
	23/11/89	110 tr	0	0	5
	27/11/91	94 tr	1	0	10
	27/11/92	53 tr	0	0	10
	3/12/95	145 tr	0	1	10
	11/12/96	-	0	6	10
	10/12/97	108	0	7	10
No.6 Sandbank	5/6/80	0	0		10
	4/6/81	0	0		10
No.1 Sandbank	14/11/84	13 (tr)	0		10
Ham Cay	12/12/79	61# tr	0		5
	5/6/80	0	0	0	10
	16/11/81	Many tr	0	0	10
	11/12/82	Many tr	0	0	10
	25/11/89	10 tr	0	0	5
Derry Cay	5/6/80	0	0	0	10
	12/12/82	12 tr	0	1	10
	25/11/89	~12 tr	0	0	5
Davie Islet	27/6/81	0	0		10
	12/12/82	14 tr	0	0	10
	23/11/89	22 tr	0	0	5
Tydeman Cay	27/6/81	0	0		10
	12/12/82	29 tr	0	0	10
	18/12/86	11 tr	0		10

1980b). The more tropical location of the Raine Island rookery and the extremely large numbers of breeding females at Raine Island would give a higher chance of a few individuals nesting outside the main breeding season and could be the cause of the expanded breeding season compared to elsewhere in the GBR.

There is considerable variability in the timing of *C. mydas* breeding throughout the Australian continental shelf. Along the eastern and western Australian coasts, *C. mydas* nesting is principally mid-summer. Within the southern Gulf of Carpentaria (Bountiful, Pisonia and Rocky Islands) and Arafura Sea (southern islands of Aru Archipelago), *C. mydas* nesting occurs year round with a midyear peak (Bustard, 1972; Schulz, 1989; C.J. Limpus, unpubl. data). A similar variability in breeding season occurs for *N. depressus* at its various rookeries around northern Australia (Limpus, 1971; Limpus et al., 1983b, 1989).

This variability in timing of the nesting season probably results from the interaction of a number of factors which should include the temperature environment of the rookery (Guinea, 1994), the genetic origin of the breeding population (which, amongst other things, should influence the pivotal temperature for the individual population) and the climate of the feeding grounds providing turtles to the rookeries. The direct cause(s) for this variability in breeding season cannot be explained at present. It is not simply a function of latitude, given the similarity of the breeding seasons in northern and southern GBR and the different breeding season of the southern Gulf of Carpentaria rookeries at an intermediate latitude. The issue is further complicated by turtles from widely scattered

TABLE 6. Coral cays, continental islands and mainland beaches of the inner shelf of the northern Great Barrier Reef. Cm = *Chelonia mydas*; Ei = *Eretmochelys imbricata*; Nd = *Natator depressus*; ? = species unidentified. See Table 3 for other symbols and codes.

Rookery	Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Notes
Sinclair Island	11/12/76	0	0		5
Milman Island	11/12/76	(6) Ei	0		5
	5/12/78	~10 tr Ei	0		7
	31/7/82	~16# tr Ei	0		10
	13/6/84	~5# tr Ei	0		5
Cholmondely Island	1/8/82	3# tr Ei	0		10
Wallace Island	7/12/76	4 tr Ei	0		5
	09/12/76	0	0		
	1/8/82	1# ? 2# tr Ei	0	0	10
Mainland coast south of Usher Point	10/12/76	0	0		5
Little Boydong Island	9/12/76	0	0		5
Boydong Island	9/12/76	(2) Ei	0	0	5
	1/8/82	8# tr Ei	0	0	10
Hannibul Island	6/3/75	1 tr Ei	0		2
Bird Island (north)	5/3/75	(4) Ei	0	0	2
	8/12/76	(1) Cm (3) Ei	0	0	5
	21/6/81	1 tr Ei	0		10
	13/6/84	1# tr Ei			5
Bird Island (south)	21/6/81	1 tr Ei	0		10
Macarthur Island	6/3/75	1 tr Ei	0		2
Saunders Island	5/3/75	2 tr Ei	0	0	2
	21/6/81	1 tr Ei	0		10
	2/8/82	1 tr Ei	0	1 Ei	10
Ellis Island	11/11/79	0	0		5
Magra Island	22/6/81	3# tr Ei	0		10
Ashmore Banks (north western)	1/12/76	2 tr Cm 1 tr Ei	0		5
	7/8/80	1 Ei	0		10
	6/6/81	0	0		10
Ashmore Banks (north eastern)	7/6/81	0	0		10
Ashmore Banks (north eastern)	7/6/80	1 tr/Cm	0	0	10
	7/6/81	0	0		10
Farmer Island	23/4/83	0	0		10
	20/12/85	2 tr Ei	0	0	10
	21/12/85	(6) Ei			
	2/6/86	1 tr Ei	0		10
	28/11/87	2 tr Ei 2# tr Cm	0	0	10
	29/11/87	(5) Ei	0	0	10

Rookery	Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Notes
Sir Charles Hardy Island (northern)	26/10/79	3# tr ?	0		5
	26/6/80	1# tr Ei	0	0	10
	11/11/81	1 tr Cm (1) Ei	0	0	10
	19/12/85	1# tr Cm 4# tr Ei	0	0	10
	5/12/87	9# tr Cm 2# tr Ei	0		10
Sir Charles Hardy Islands (western)	2/12/76	11# tr ?	0		5
	26/10/79	13# tr ?	0		5
	28/7/82	0	0		10
	23/4/83	0	0		10
	19/12/85	1# tr ?	0	0	10
	5/12/87	11# tr ? 2# tr Ei	0		10
Haggerstone Island	10/11/79	0	0		5
	22/6/81	0	0		10
	23/6/81	0	0		
	15/11/81	1 tr Ei	0	0	10
	28/7/82	0	0		10
	30/4/83	0	0		10
	5/12/87	0	0		10
Forbes Island (north)	15/11/81	0	0	0	10
Portland Roads	30/11/76	0	0		5
	30/4/83	0	0		10
Quoin Island	6/6/80	0	0	0	10
	24/6/81	0	0		10
	15/11/81	0	0	0	10
	26/11/89	0	0		5
Chapman Island	17/12/79	0	0		5
	17/11/84	0	0		10
Sherrard Island	17/11/84	1# tr ?	0		10
	6/12/87	1# tr Cm 3# tr Ei	0	0	10
Night Island	25/1/79	0	0		5
	9/11/81	0	0	0	10
	9/11/82	0	0		10
	12/6/84	0	0		5
	16/11/84	0	0		10
Morris Island	6/12/87	13# tr Cm 12# tr Ei	0	0	10
Fife Island	28/11/76	3 tr Ei		0	5
	9/11/82	0	0	0	10
	12/6/84	0	0	0	5
	6/12/87	6# tr Ei	0	0	10
Lowrie Island	9/11/82	0	0	0	10

TABLE 6 (*Cont.*)

Rookery	Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Notes
Hay Island	9/11/82	0	0	0	10
	16/11/84	2# tr Ei	0	0	10
Hannah Island	27/11/76	0	0	0	5
	9/11/82	0	0	0	10
	15/11/84	0	0	0	10
Pelican Island	28/11/76	0	0	0	5
	26/6/81	0	0	0	10
	9/11/81	1 tr Ei 1 Nd hatchling	0	0	10
	16/11/83	1# tr Cm 2# tr Ei		0	12
	7/12/87	2# tr Ei	0	0	10
Stainer Island	11/6/84	0	0	0	5
	15/11/84	3# tr Ei	0	0	10
	7/12/87	0	0	0	10
King Island	14/11/84	0	0		10
Clack Island	19-21/12/86	0	0	0	10
Stanley Island	25/2/75	0	0		2
	18/11/81	0	0	0	10
Flinders Island	24/10/79	0	0		5
	18/11/81	0	0	0	18
	15/11/84	0	0		10
Pipon Island	22/2/75	0	0	0	2
	29/6/81	0	0		10
	14/11/84	0	0		10

Rookery	Date	Nightly count No. ashore	Nightly count Death rate	Accumulated dead turtles	Notes
Cape Melville	12/11/79	0	0		5
	18/11/81	0	0	0	10
	8/12/87	0	0		10
Stapleton Island	29/6/80	0	0		10
	13/11/84	2# tr Cm	0	0	10
Coombes Island	14/11/84	0	0	0	10
Noble Island	18/11/81	0	0	0	10
Rhodda Cay	27/6/81	0	0		10
Wilson Cay	27/6/81	0	0		10
Howick Island	23/10/79	0	0		5
Holm Island	14/11/79	0	0		5
Barnard Island	14/11/79	0	0		5
Eagle Islet	27/6/81	0	0		10
North Direction Island	28/6/81	0	0		10
South Direction Island	28/6/81	0	0		10
Rocky Islet	28/6/81	0	0		10
	14/12/82	0	0	0	10
Three Isles	21/2/75	0	0		2
Low Wooded Isle	3/6/80	0	0		10
Low Island	22/10/79	0	0		5
Michelmas Cay	1/6/80	0	0		10
	30/6/81	0	0		10

rookeries oeeurring together in feeding grounds in northern Australia and adjaeent eastern Indonesia (Limpus et al., 1992). For example, adult female *C. mydas* have been eaught off Coburg Peninsula in the Northern Territory that had been tagged while nesting at Raine Island, Laeepede Islands in Western Australia and south eastern Java; others have been eaught in the Kei Islands of Indonesia that had been tagged while nesting at Raine Island and at the Turtle Islands of Sabah.

HOW LONG HAS RAINE ISLAND BEEN A *CHELONIA MYDAS* ROOKERY? Prior to the last Holocene transgression of some 10,000 yr ago, a turtle swimming up to the reef on whieh Raine Island now lies would have been eonfronted with preeipitous eliffs rising to perhaps 45m or more above the then sea level with no beaches suitable for turtle nesting. Indeed, there may have been no suitable beaches for turtle nesting anywhere in the vieinity. The present day Raine Island and the other islands of the northern outer Great Barrier Reef have formed sinee sea levels stabilised at an upper level approximately 6,000 yr ago and slowly reeeded about 1m to their current level more than 4,000 yr ago (Hopley, 1983; Chappel, 1983).

Clam shells (*Tridacna* sp. and *Hippopus hippopus*) embedded in the surfaee of the phosphatie limestone platform of Raine Island have been earbon dated to a ealibrated age B.P. of 1130 ± 210yr at the western end of the island and as low as 590 - 630 ± 70yr at the eastern end of the island adjaeent to the tower (Limpus, 1987; Polaeh et al., 1978). Deeper layers of roek are presumed to be older. The other sand eays of the

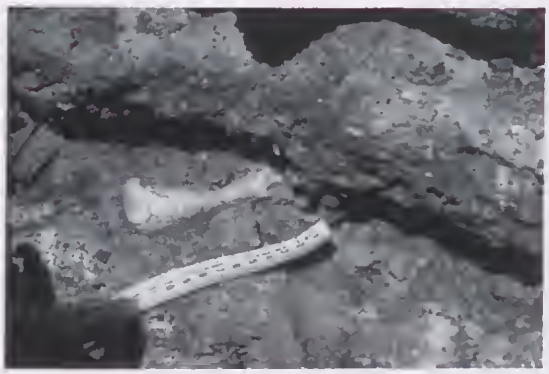

FIG. 14. Fossil remains of an adult sized *Chelonia mydas* (femur) found at the western end of Raine Island in a bedding plane approximately 60cm below a clam carbon dated to 1130yr B.P.

FIG. 15. Skeletal remains of an adult female *Chelonia mydas* that had been disoriented and died of heat exhaustion in the central depression of Raine Island. This carcass, photographed in December 1987, originated from a turtle that died during the 1984-85 breeding season. Skeletal remains in this central area of the island have the potential for being left undisturbed for years and subsequently buried.

northern outer barrier reef are presumed to be of similar age to Raine Island.

Turtle eggs in nests fossilised in situ were reported during the quarrying of the phosphatic limestone platform at the eastern end of the island for the construction of the beacon (MacGillivray, 1846; Jukes, 1847). This quarry site is adjacent to the beacon and within 50m of the collection site of the clams dated 590-630yr BP. These clutches of turtle eggs must have been laid at least 460 yr before their discovery in 1844.

The weathered fossil remains of an adult-sized *C. mydas* that had died plastron down and whose skeletal remains were relatively undisturbed prior to being covered by sand were found in a horizontal bedding plane approximately 60cm below the clam dated at 1130yr BP. (Limpus, 1987) (Fig. 14). Fragments of turtle bone and bird bone can be found in almost every large phosphatic limestone rock at the margin to the central rock platform of Raine Island.

Death of nesting turtles ashore for nesting attempts has been observed annually on Raine Island during the recent studies and in seasons of high nesting density there may be >1,000 skeletons added to the islands sediments (Table 6). Most of these are scattered as individual bones by subsequent nesting turtles. Only the skeletons of turtles that die in the central depression of the rock platform are likely to be left relatively undisturbed (Fig. 15). It is also only during seasons of high nesting density that numerous turtles enter the central depression and die there of heat exhaustion. Raine Island and Moulter Cay are the only turtle rookeries of the GBR where nesting turtles die in large numbers and where turtle bones are a characteristic of the beach sediments. This turtle mortality is a function of the high density turtle nesting that occurs on these islands. The first accounts of Raine Island from 1843-4 prior to quarrying for construction of the beacon (MacGillivray, 1846; Jukes, 1847) described Raine Island with its turtle bones and dead turtles in a manner consistent with its appearance today. Numerous turtle remains and dead and dying turtles have impressed subsequent visitors to Raine Island in 1845 (Allen & Corris, 1977), 1874 (Moseley, 1879), 1890 (Ellis, 1936), 1913 (MacGillivray, 1917) and c.1953-6 (Fig. 1).

Taken together these observations indicate that Raine Island has supported a high density *C. mydas* rookery with associated frequent adult turtle mortality for long before its discovery by Europeans and indeed, for at least 1190 ± 210 yr B.P. (Limpus, 1987). However turtles could not have been using the island for nesting for more than about 4000 yr (the time that a sand island could have existed on this reef). This is the only marine turtle rookery in Australia with long-term evidence of nesting prior to European colonisation. Because of this fossil evidence for past nesting, Raine Island has the longest continual record of use as a marine turtle rookery anywhere in the world (Groombridge & Luxmore, 1989).

The origin of the turtles that colonised Raine Island after its formation perhaps 4000 yr ago has not been elucidated as yet by genetic studies of

TABLE 7. Numbers of adult female *Chelonia mydas* tagged and recaptured while nesting at Raine Island 1974-2001. AE indicates turtles tagged by Applied Ecology P/L. All other tags applied by QPWS. OR denotes tagged turtles recorded during Operation Raleigh. * denotes migration recaptures of nesting turtles previously tagged at foraging area. In no season was an attempt made to tag the entire nesting population. For remigrant turtles that changed rookeries between breeding seasons, the original rookery was identified: CS = Coral Sea Platform; MC = Moulter Cay; MM = Milman Island; MP = Moore Park; N7 = No. 7 sandbank; N8 = No. 8 Sandbank; RI = Raine Island.

Breeding season	Month	New tags	Within season rookery change	Remigrant			New turtles to rookery	Total turtles with tags
				Same rookery	Rookery change	Retag		
1974-75	Feb-Mar	151					151	151
1975-76								Nil
1976-77	Dec	2420 15 AE	0	0	0	0	2435	2435
1977-78	Dec	53 61 AE	0	0	0	0	114	114
1978-79	Dec	490 398 AE	0	0	0	0	888	888
1979-80	Oct-Dec	1766	0	1	0	0	1766	1767
	June	1	0	0	0	0	1	1
1980-81	Dec	284	0	0	0	0	284	284
	June	1	0	0	0	0	1	1
1981-82	Nov-Dec	2589	0	8 1 AE	1 MC	4	2591	2603
	Jul	2	0	0	0	0	2	2
1982-83	Nov-Dec	1586	0	8	0	7	1586	1601
	April	6	0	0	0	0	6	6
1983-84	Apr	80	0	0	0	0	80	80
1984-85	Nov- Dec	2458 2*	0	59	0	25	2460	2544
1985-86	Nov- Dec	1853 1*	2 MC	31	1 N8	30	1857	1918
1986-87	Nov- Dec	1447	0 12 OR	80	1 N8	177	1460	1717
1987-88	Jul- Aug	4	0	0	0	0	4	4
1988-89	Nov-Dec	1859	0	63	0	29	1859	1951
1989-90	Dec	769	0	264	0	4	769	1037
1990-91	Dec	1210	0	148	1 MC	24	1211	1383
1991-92	Dec	980	0	227	0	17	980	1224
1992-93	Dec	1689	0	129	0	14	1689	1832
1993-94	Dec	1593 6 *	0	152	1 N7	5	1600	1757
1994-95	Dec	991	0	31	1 N7	1	992	1024
1995-96	Dec	1485 1*	0	136	3 MC	43	1489	1668
1996-97	Nov-Dec	1664 9*	0	289	2 MC	28	1675	1992
	Jan-Feb	796 1*	0	91	3 N8	5	800	896
1997-98	Nov-Dec	1022 5*	0	387	1 N8 1 CS	11	1029	1427
1998-99	Nov-Dec	1599	0	156	0	31	1599	1786
1999-00	Nov-Dec	1160 17*	0	847	7 MC 3 MM 3 N7 1 N8	29	1191	2067
2000-01	Nov-Dec	664 1*	0	72	0	19	665	756
2001-02	Dec	1145 4*	0	443	3 N8 2 M 2 N7 1 MM 1 MP	27	1158	1628
Total		33817 474 AE 47*	2MC 12 OR	3622 1 AE	16 MC 10 N8 7 N7 4 MM 1 MP 1 CS	530	34392	38544

TABLE 8. Numbers of adult female *Chelonia mydas* tagged and recaptured while nesting at Moulter Cay, northern GBR, 1974-2001. See Table 7 for definition of codes.

Breeding season	Month	New tags	Within season rookery change	Remigrant			New turtles to rookery	Total turtles with tags
				Same rookery	Rookery change	Retag		
1974-75	Mar	6	0	0	0	0	6	6
1976-77	Dec	425	5 RI	0	0	0	430	430
1977-78	Dec	6 4 AE	0	0	0	0	10	10
1982-83	Dec	2	0	0	0	0	2	2
1984-85	Dec				1 RI		1	1
1985-86	Dec	131	11 RI	0	0	0	142	142
1986-87	Dec	174	8 RI	1	2 RI	11	184	196
1988-89	Dec	98	1 RI	0	2 RI	0	101	101
1989-90	Dec	72	0	1	0	0	72	73
1990-91								Nil
1991-92								Nil
1992-93	Dec	48	0	2	1 RI	2	49	53
1993-94								Nil
1994-95								Nil
1995-96	Dec	94	2 RI	2	1 RI 1 N7	3	98	103
1996-97								Nil
1997-98	Dec	109	13 RI	1	5 RI 1 MM	0	128	129
1998-99	Dec	194	2 RI	0	1 RI	1	197	198
1999-00	Dec	132	3 RI	1	7 RI 1 MM	0	143	144
2000-01	Dec	81	0	0	1 RI	2	82	84
2001-02	Dec	272	5 RI	5	0	2	77	291
Total		1844 4 AE	50 RI	13	21 RI 1 N7 2 MM	21	1922	1956

world wide *C. mydas* populations (Bowen et al., 1989; Norman et al., 1994a,b). Given the precipitous nature of the coastline for that part of Australia in pre Holocene times, the present day rookeries are not the result of a gradual shift of beaches with rising sea levels. Entirely new beaches became available for colonisation following the sea level rise while others, presumably further afield, were submerged. This emphasises the capacity for *C. mydas* to colonise new rookeries that were not natal beaches in response to slow changes in sea level. The process by which turtles locate and/or choose a new rookery site following the elimination of an existing one has not be addressed by present studies.

COURTSHIP. *C. mydas* courtship observed during expeditions to Raine Island is summarised as follows:

1979. 29 October - 9 November: Mating pairs of *C. mydas* were a comon sight in the deep water just outside the reef edge; two pairs of mating *C. mydas* were captured while stranded on the reef flat. 13-14 December: No courting turtles were observed, although the females were still aggregated in large numbers over the reef and beyond the reef edge.

1980. 8-13 December: No turtle courtship observed on or near Raine Island Reef.

1982. 13-31 July: One mounted pair of *C. mydas* observed adjacent to Raine Island Reef. 11 November - 10 December: Courting *C. mydas* were observed adjacent to Raine Island reef on only a few occasions in mid November.

1984. 3-26 April: No courtship observed on or near Raine Island Reef. Vertical aerial photographs of Raine Island from October 1984, commissioned by the Raine Island Corporation, show hundreds of large turtles aggregated in the shallows of the reef flat adjacent to the island. The aggregation in these images resembled of aggregations of mating *C. mydas* observed by the authors at rookeries in the southern Great Barrier Reef and the Wellesley Group in the southern Gulf of Carpentaria.

1985. 9 & 16 December: During underwater observations, adult male turtles were seldom seen (2 males out of 36 *C. mydas* examined). One male had recent courtship damage (Limpus, 1993) to tail and flippers.

TABLE 9. Adult female *Chelonia mydas* tagged and recaptured while nesting at other outer barrier cays in the northern GBR, 1974-2001. See Table 7 for definition of codes.

Breeding season	Month	New tags	Within season rookery change	Remigrant			New turtles to rookery	Total turtles with tags
				Same rookery	Rookery change	Retag		
Maclennan Cay								
1978-79	Dec	2 2 AE	0	0	0	0	4	4
1988-89	Dec	8	0	0	0	0	8	8
Subtotal		10 2 AE	0	0	0	0	12	12
No 7. Sandbank								
1976-77	Dec	1	0	0	0	0	1	1
1986-87	Nov	74	0	0	0	0	74	74
1987-1988	Nov	62	0	0	0	0	62	62
1988-89	Nov	26	0	0	0	0	26	26
1990-91	Dec	12	0	0	0	0	12	12
1991-92	Dec	89	0	0	0	0	89	89
1992-93	Dec	53	0	0	0	0	53	53
1995-96	Dec	70	0	1	0	2	70	73
1996-97	Dec	50	0	11	3 N8	0	53	64
1997-98	Dec	45 1*	0	2	0	0	46	48
Subtotal		482 1*	0	14	3 N8	2	486	502
No. 8 Sandbank								
1976-77	Dec	15	0	0	0	0	15	15
1979-80	Dec	34	0	0	0	0	34	34
1981-82	Dec	1	0	0	0	0	1	1
1982-83	Dec	71	0	0	0	0	71	71
1986-87	Nov	102	0	0	0	4	102	106
1987-88	Nov	122	0	0	0	0	122	122
1988-89	Nov	30	0	0	0	0	30	30
1989-90	Dec	10	0	0	0	0	10	10
1990-91	Dec	24	0	2	0	0	24	26
1991-92	Dec	70	0	0	0	1	70	71
1992-93	Dec	60	0	3	0	0	60	63
1995-96	Dec	77	0	1	0	2	77	80
1996-97	Dec	53	0	1	1 N7	0	54	55
1997-98	Dec	67	0	3	0	1	67	71
Subtotal		736	0	10	1 N7	8	737	755
Ham Cay								
1981-82	Dec	1	0	0	0	0	1	1
Bramble Bay Cay								
1989-90	Jan	110	0	0	1 R1	0	111	111
Total		1341 1*	0	24	1 N7 3 N8 1 R1	10	1347	1381

1986. 22 November - 16 December: Several courting pairs of *C. mydas* were observed daily during the early part of the study. No mating pairs were seen after 8 December. During underwater observations on 10 and 14 December, adult male turtles were seldom seen (5 males out of 263 *C. mydas* examined).

1987. 10 July - 19 August: Four mounted pairs of *C. mydas* observed, two pair each with an attendant male. 28 November: One pair of courting *C. mydas* seen on No.7 Sandbank Reef. None seen on No.8 Sandbank Reef. 30 November - 5 December: Only a few isolated pairs of courting *C. mydas* observed adjacent to Raine Island. During underwater observations on 1-5 December, adult male turtles were rarely seen (only 5 males out of 1144 *C. mydas* examined during speedboat transects).

TABLE 10. Adult female *Eretmochelys imbricata* tagged while nesting at coral cays and continental islands along the inner shelf of the northern GBR, 1975- 1989. No *Chelonia mydas* were tagged while nesting on the inner shelf islands during this period.

Breeding season	Month	New tags	Within season rookery change	Remigrant			New turtles to rookery	Total turtles with tags
				Same rookery	Rookery change	Retag		
Farmer Island								
1985-86	Dec	2	0	0	0	0	2	2
1987-88	Nov	2	0	0	0	0	2	2
Sir Charles Hardy Islands								
1981-82	July	1	0	0	0	0	1	1
Bird Island								
1974-75	Mar	3	0	0	0	0	3	3
1976-77	Dec	3	0	0	0	0	3	3
Boydong Island								
1976-77	Dec	1	0	0	0	0	1	1
Milman Island								
1976-77	Dec	6	0	0	0	0	6	6
Combined	18	0	0	0	0	0	18	18

1989. 28 November - 07 December: No courting turtles observed on or near Raine Island Reef.

1991. 29 November - 10 December: 2 courting pairs near Raine Island Reef.

1992. 29 November - 10 December: 3 courting pairs near Raine Island Reef.

1993. 29 November - 10 December: 3 courting pairs near Raine Island Reef.

1994. 30 November - 9 December: 2 courting pairs near Raine Island Reef; 12 males with courtship damage captured during reef survey.

1995. 5 - 13 December: No courting turtles observed on or near Raine Island Reef; 21 males recorded during reef survey.

1997. 29 November - 6 December: 2 courting pairs observed near Raine Island Reef; 2 males recorded during reef survey.

1999. 28 November - 11 December: 1 courting pair observed near Raine Island Reef; 4 males recorded during reef survey.

2000. 28 November - 9 December: 1 courting pairs observed near Raine Island Reef; 2 males recorded during reef survey.

2001. 1 - 10 December: No courting turtles observed on or near Raine Islamnd Reef; 0 males recorded during reef survey.

Courting *C. mydas* were rarely observed at any of the other rookeries of the northern outer barrier reef after mid November. The only time when frequent courtship was observed was in late October - early November. This is consistent with the pattern of courtship relative to nesting observed in the southern GBR where *C. mydas* aggregates for courtship during late September, October and early November, after which courting turtles are rarely seen (Limpus, 1993).

Insufficient courtship was in evidence close to Raine Island and Moulter Cay to account for the large nesting population. No fisherman reported seeing aggregations of hundreds of courting pairs near these islands, which would be expected if the turtles courted adjacent to the rookeries. Reports from fishermen indicated high density courtship occurred in the shallow protected waters north of Cape Grenville in October. The Torres Strait islanders encounter large numbers of courting *C. mydas* during September, October and early November throughout Torres Strait. This favoured turtle hunting time is called 'turtlefast', i.e. the time when the male turtle is fastened onto the female (Johannes & Macfarlane, 1991). The years with a big turtle-fast correspond to the high density nesting seasons and poor turtle fast years are the years in which low density turtle nesting occurs. There is insufficient *C. mydas* nesting within Torres Strait to account for the courtship that occurs there. Therefore it is concluded that the majority of the courtship that occurs within Torres Strait is by turtles that nest at Raine Island and Moulter Cay. If this is the case then significant levels of courtship could be occurring up to 200km from the rookeries. This spatial separation of the courtship area from the immediate vicinity of the female's rookery characterises much of the *C. mydas* courtship in the southern GBR (Limpus, 1993).

TABLE 11. Raine Island. Summary of turtle nesting accounts by month to determine the seasonality of the *Chelonia mydas* nesting. Unless otherwise stated the raw data has been obtained from the recent surveys of nesting density - Tables 2-4.

Month	Year	Day	Observations
July	1843	29	A few turtle tracks (Jukes, 1847)
	1844		Turtles occurred at irregular intervals, generally singularly (MacGillivray, 1914)
	1911	9-15	No reference to turtle nesting or to bird predation on hatchlings (MacGillivray, 1914)
	1957	20-25	Average 5 turtle tracks per night (Attenborough, in Litt. 4 Apr.1981).
	1982	13-28	0-2 turtles per night.
August	1844		Turtles occurred at irregular intervals generally singularly (MacGillivray, 1914)
	1871	31	No reference to turtle nesting (Moseley, 1879)
September	1844		Beginning in September they become more numerous (MacGillivray, 1846)
	1984	1	7 tracks
October	1910	30	Great numbers of turtles are on the beach and in the shallows around the boat (MacGillivray, 1910)
	1975	Early	Approximately 50 females per night
	1979	30-31	381 - 451 tally count
	1986	17-18	123 - 137 tally count
November	1965		Was able to step or jump from turtle to turtle while a companion walked 100 paces beside him (P. Watson, pers. comm. 1979).
	1973	1-3	About 150 - 200 females per night (track count, Stoddart et al. 1981)
	1974	29	11565 female on shore
	1977	early	Approximately 40 - 50 females per night
	1979	1-9	410 - 444 tally count
	1981	12-30	906 - 2757 tally count
	1982	13-30	452 - 1095 tally count
	1984	21-30	5179 - 7739 tally count
	1985	25-30	119 - 308 tally count
	1986	13-30	1284 - 4565 tally count
	1987	30	3296 tally count
	1989	29	5919 tally count
December	1913	4-12	Reference to obvious frequent clutch destruction by nesting turtles. Turtles abundant in the shallows and beach edge and the party 'tormented at night by the nesting turtles who persist in trying to walk over or under our sleeping shelter'. While at Moulter Cay 'thousands of turtles' came ashore for the night (MacGillivray, 1917). Moulter Cay described as a 'turtle- infested sand-bank' (MacGillivray, 1918b).
	1976	2-6	845 - 898 tally count
	1977	3-7	19 - 53 females per night
	1978	1-5	148 - 327 females per night
	1979	13-14	1211 - 1482 tally count
	1980	8-12	80 - 83 females per night
	1981	1-13	1287 - 3463 tally count
	1982	1-7	809 - 1091 tally count
	1984	1-23	3916 - 11467 tally count
	1985	1-20	142 - 323 tally count
	1986	1-15	2910 - 4838 tally count
	1987	1-5	2312 - 4585 tally count
	1988	1-7	516 - 1088 tally count
	1989	5-7	5925 - 6516 tally count
January	1845	28	14 large turtles collected (MacKenzie, 1845).
	1953-6?		(May have been February) Estimated 10000-12000 green turtles ashore in one night (V. Vlassoff, pers. comm.1981)
	1959		Dense turtle nesting sufficient to allow people to 'walk long distances along the beach from turtle to turtle' (E. Gray, pers. comm. 1983). At least 1100 turtles counted in one walk of the island in one night (N. Whittaker, pers. comm. 11 Aug. 1983).
	1974	Late	Several hundred turtle tracks counted by daylight (Ben Cropp, pers. comm. 1975)
	1976	29	Approximately 80 tracks (J. Kowarsky, pers. comm. 1977)
February	1959	7-14,22	'Hundreds were coming ashore after dark' (Warham, 1963)
March	1975	1-3	408 - 517 females per night
	1981	1-9	10 - 36 females per night

TABLE 11 (*Cont.*)

April	1980	8	1 - 2 females per night
	1983	25-29	1 - 8 females per night
	1984	3-26	2-17 females per night
April-May	1845	28-4	Estimated harvesting rate = 2 turtles per night, calculated from Sweatmans account. (Allen & Corris, 1977)
May			No Records
June	1844		Turtles occurred at irregular intervals generally singularly (MacGillivray, 1846)
	1980	9-23	Average < 1 female per night
	1981	7-18	Average < 1 female per night

Only 45 adult male *C. mydas* have been tagged at Raine Island and adjacent islands (Table 12). All of these were breeding males that were captured in courting groups or had recent mating scars on their flippers or tails. Adult males have been recorded only at low density adjacent to these outer barrier rookeries in the northern GBR.

BASKING. *C. mydas* at Raine Island were not observed to haul out onto the beach or onto the reef flat at low tide to bask during any visit. In contrast, vertical aerial photographs of Raine Island from October 1984 show about 100 adult-sized turtles, presumably *C. mydas*, scattered along the tide line of the beach. While most were in the water, tens were above the tide wash. On very calm days during the nesting season large numbers of adult turtles could be seen floating high (with dry carapaces) at the surface for extended periods at the reef edge and over the adjacent deep water. This behaviour is defined as surface basking and is presumed to have a thermoregulatory function. Aggregations of surface basking turtles were only observed adjacent to Raine Island Reef and Moulter Cay Reef.

Beach basking is a prominent behaviour of *C. mydas* at the Wellesley Islands of the south-eastern Gulf of Carpentaria (Limpus et al., 1994a; Bustard, 1972) and on the Capricorn-Bunker

TABLE 12. Summary of non nesting turtles tagged on Raine Island reef and other reefs of the far northern GBR. AE = tagged by Applied Ecology P/L. This table does not include the mid year tagging of turtles at Clack Reef that has been conducted as part of an independent study.

Breeding Season	Month	Size Class				Total for trip
		Adult		Immature		
		male	female	CCL >65cm	CCL <65cm	
Chelonia mydas						
Raine Island Reef						
1977-78	Dec	0	0	1	0	1
1978-79	Dec	12 12 AE	0	0	0 1 AE	25
1979-80	Oct-Dec	3	0	1	0	4
1982-83	Jul	1	0	1	1	3
1986-87	Dec	0	0	0	1	1
1987-88	Jul-Aug	2	0	1	0	3
	Nov-Dec	3	0	5	2	10
1988-89	Dec	0	0	1	0	1
1994-95	Nov-Dec	12	0	0	0	12
Combined	45	0	10	5	60	
Pipon Reef						
1974-75	Feb	0	2	0	0	2
Milman Island Reef						
1978-79	Dec	0	0	4 AE	6 AE	10
Maclennan Cay						
1978-79	Dec	2	0	0	0	2
MacArthur Cay Reef						
1985-86	Jul	0	0	0	1	1
Clack Reef						
1986-87	Dec	0	0	2	3	5
1987-88	Dec	0	1	6	4	11
Corbett Reef						
1988-89	Dec	25	0	0	0	25
Howick Reef						
1988-89	Dec	0	0	0	4	4
Beanley Reef						
1988-89	Dec	0	0	0	2	2
Bewick Reef						
1988-89	Dec	0	0	0	1	1
Combined	27	3	8 4 AE	15 6 AE	63	
Eretmochelys imbricata						
Corbett Reef						
1987-88	Dec	3	0	0	0	3
Bewick Reef						
1988-89	Dec	0	0	0	1	1
Combined	3	0	0	1	4	

Group cays in the southern GBR (Barrett, 1919). Beach basking is also a common behaviour of the Hawaiian *C. mydas* population (Balazs, 1980). This contrasts with its apparent rarity within the northern GBR *C. mydas* population. This is not just a recent phenomenon; beach basking does not feature in any of the historical accounts of *C. mydas* in the northern GBR (see above).

MORTALITY OF BREEDING FEMALES ON THE NESTING BEACHES

MORTALITY RATE. The earliest records show that regular mortality of the female *C. mydas* while ashore attempting to nest has long been a feature of Raine Island (Jukes, 1847; MacGillivray, 1846; Moseley, 1879; Macgillivray, 1917; V. Vlassoff, pers. comm. 1981, fig. 11; Warham, 1963). Tables 3-4 show that this adult female mortality continues in present times. From these tables, a comparison of daily mortality and the number of turtles recorded ashore was made (Fig. 16). Daily adult mortality was dependent on the number of nesting turtles ashore on the previous night. Turtles did not usually die if there were less than 100 females ashore for the night: 95% of nights with no subsequent mortality; 5% with 1 death/day (n=43 days). Daily turtle mortality was still low when the nightly tally counts were in the range of 100-1000 turtles: 71% of nights with no subsequent mortality; 22% with 1 death/day; 7% with 2-12 deaths/day (n=69 days). In contrast when the nightly tally counts exceeded 1,000 there was a substantial increase in daily mortality and there were few days with no turtle mortality: 7% of nights with no subsequent mortality; 2% with 1 death/day; 91% of days with 2-75 deaths/day (n=126 days). Nightly tally counts had to exceed 800 nesting females before the number of dead exceeded 1/day. There was a significant correlation between the daily mortality and the tally count on the preceding night:

daily death rate = 0.003415*tally count - 1.376 (r^2=0.526; d.f.=137. $F_{1,137}$=152; p<0.0005)

Therefore, through the course of a summer breeding season it can be expected that daily mortality rates will increase to a maximum during the mid nesting season and then decline to zero as the season draws to a close. Fig. 17 shows the cumulative mortality during the early part of six breeding seasons representing a wide range of nightly nesting density: 1981/82, 1982/83, 1984/85, 1985/86, 1986/87, 1999/00. With an assumed peak nesting not being completed until mid January then the cumulative 1981/82 adult mortality could have been in the 400-500 range. A count of carcasses in July 1982 was 189 but many carcasses known to have been present earlier in the season had been broken up and/or buried. In April 1983 the 83 carcasses recorded from the preceeding breeding season was also an underestimate because some known carcasses had been lost in the sand, even though the season's nesting density was lower. An end-of-season count of carcasses is thus likely to give a substantial underestimate of annual mortality if the count is not made on a daily basis, especially in years with high density nesting. The large counts of turtle carcasses of 281 in November and 588 in March of the 1974/75 nesting season (Table 3) must be taken as underestimates of the adult mortality during that high density nesting season. The annual mortality of nesting females on Raine Island probably is expected to be negligible in very low density nesting seasons like 1977/78 and 1985/86. It could be approaching 100 in low density nesting seasons like 1982/83 and greater than 2000 in very high density nesting seasons like 1984/85, 1996/97 and 1999/00.

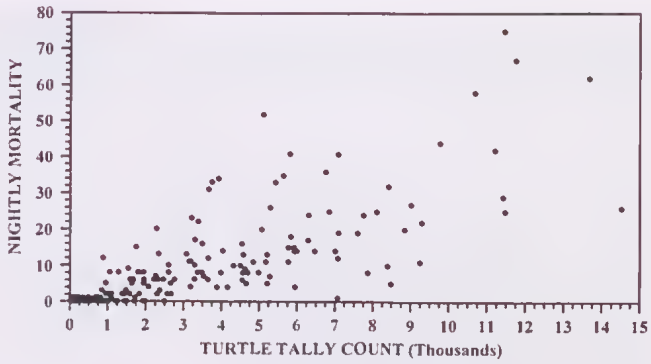

FIG. 16. Nightly mortality rate of adult female *Chelonia mydas* ashore for nesting on Raine Island (Table 3) expressed as a function of the nightly nesting density.

In any one season, far fewer turtles die while ashore nesting at Moulter Cay than at Raine Island (Fig. 17C, Table 4) and negligible numbers die annually at any one of the other outer barrier reef cays (Table 5).

Mortality of adult female *C. mydas* while ashore attempting to nest at Raine Island is clearly density dependent. This natural mortality

accounts for several thousand breeding females in high density nesting years and a few hundred or less in the low density nesting years.

CAUSES OF MORTALITY. Table 13 summarises the causes of mortality of the breeding females ashore on Raine Island. During the first 22yr of the study, 1974/75-1996/97 seasons, death from heat exhaustion of turtles that were still ashore during the first few hours of daylight was the principal cause of death (70-89% of adult turtles dying). Included in these values are those turtles that died of heat exhaustion in the central depression (2-14% of adult turtles dying). The majority of the turtles died of heat exhaustion on the beach platform. The next most prevalent cause of mortality was associated with the cliff line of the central rock platform where 8-20% of adult turtles died, mostly by falling over the cliff onto their backs. Large marine turtles cannot right themselves when they are turned on their backs.

This regular mortality of adult turtles that have come ashore at Raine Island to nest resulted from a variety of natural causes. Some turtles which found their way above the cliff during nesting attempts fell on their backs or became wedged between rocks on their return to the beach while others became trapped in the holes beneath the rock layer. A small (unquantified) proportion of these turtles was killed because their carapaces smashed down onto their heads and fractured their skulls when the fell head-first over the cliff. The remainder, lying on their backs in the sun with their pale coloured plastrons upper most, averaged 3.5 days to die (SD = 1.71, n = 33, Dec 1984). Those trapped in caves and other shaded areas sometimes took weeks to die. The cliff is a natural feature of the island and was not the result of quarrying for limestone to build the beacon or of guano mining as stated by Stannard (1985). The turtle mortality associated with the cliff is the result of natural processes.

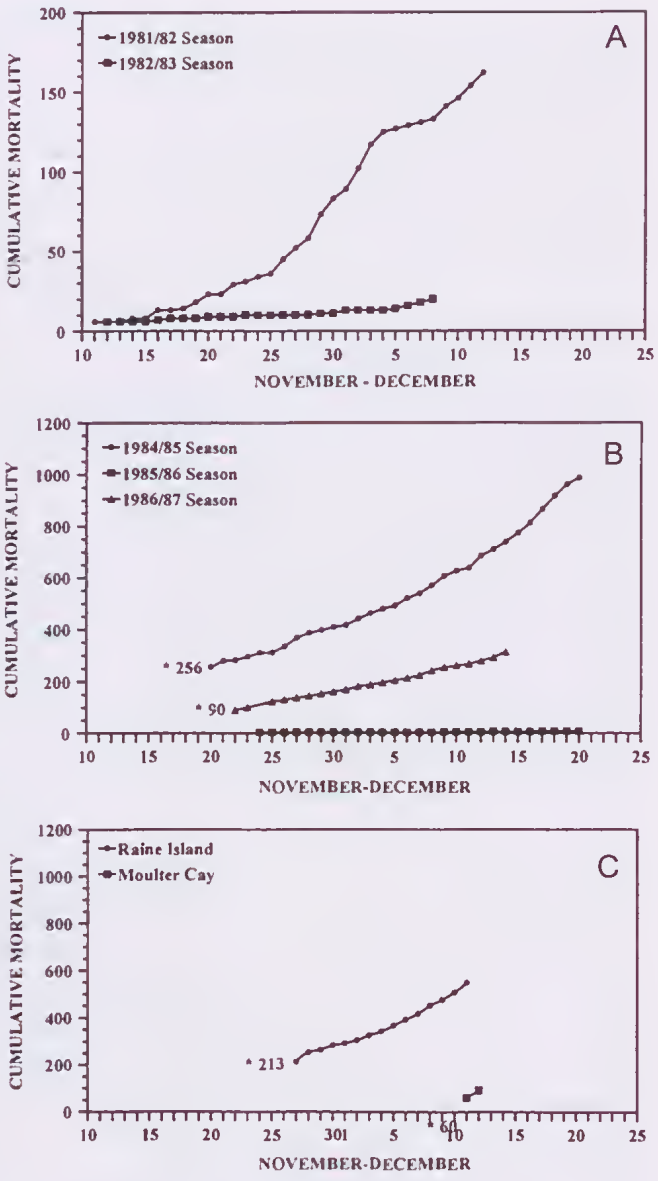

FIG. 17. Cumulative daily mortality of adult female *Chelonia mydas* on Raine Island measured over the early portion of six breeding seasons. * denotes total dead and dying recorded on arrival of the study team at the island.

The number of turtles that died by falling over the cliff was minor compared to those that died from heat exhaustion. Turtles that wandered inland into or beyond the beach depression encountered problems when endeavouring to return to the sea. When in the bottom of this depression, a turtle is exposed to an horizon line at approximately 0° elevation when looking parallel to the beach, but one at 13° when looking seaward. Because marine turtles move towards

TABLE 13. Observed causes of adult *Chelonia mydas* mortality on Raine Island. Percentage of total for observation period are given beneath the raw values. NR = not recorded. + indicates that only a portion of the actual dead turtle for the season could be accurately counted. * denotes turtles buried alive by other nesting turtles. Rescued turtles that would have died without our intervention are shown in brackets with an R prefix and are included in the adjacent count.

Study period	Cause of death							Total
	Heat exhaustion		Fell over		Trapped			
	Central depression	beach	cliff	log	Beneath cliff	In rocks	Under dinghy	
1979: 29 Oct-13 Dec	7 (14%)	33 (67%)	7 (14%)	0	2 (4%)	0	0	49
1981: 11 Nov-12 Dec	3 (19%)	106 (68.4%)	19 (12.3%) (R19)	6 (3.9%) (R3)	12 (7.7%)	8 (5.2%)	1 (0.6%)	155
Whole season count on 27 July	26							
1982: 12 Nov-9 Dec	3 (14%)	15 (71%)	3 (14%)	0	0	0	0	21
Whole season count on 27 July:	5	55+	20	0	4	0	0	84+
1983-84: Whole season count on 22 April:	9	33+	43	0	7	0	0	92+
1984: 22 Nov-23 Dec	17 (2.0%)	654 (78.0%)	135 (16.1%)	1 (0.1%)	14 (1.7%)	12 (1.4%)	5 (0.6%)	838
1985: 24 Nov-20 Dec	0	8 (80%) (R1)	2 (20%)	0	0	0	0	10
1986: 19 Nov-23 Dec	NR	251 + 2* (79.6%)	53 (16.7%)			12 (3.8%)	0	318+
1987: 26 Nov-10 Dec	5 (2.1%)	182 + 1* (77.9%)	32 (13.6%) (R14)	15 (6.4%)	0	0	0	235
1995: 3-13 Dec	1 (0.4%)	201 (73.4%) (R3)	62 (23.0%) (R36)			6 (2.2%) (R1)	0	270
1996: 27 Nov-11 Dec	NR	596 (89.5%)	57 (8.6%)			13 (2.0%)	0	666+
1997: 29 Nov-10 Dec	22 (7.9%)	107 (38.6%)	121 (43.7%)			27 (9.7%)	0	277
1998: 28 Nov-11 Dec	2 (6%)	16 (44%) (R1)	16 (44%) (R2)			2 (6%) (R1)	0	36
1999: 28 Nov-12 Dec	10 (1.8%)	240 (43.1%)	257 (46.1%)			50 (9.0%)	0	557
2000: 30 Nov-10 Dec	0	0	2			2	0	4
2001: Nov-10 Dec	92 (66.2%)		42 (30.2%)			5 (3.6%)	0	139

low elevation, bright areas on their return to the sea (Limpus, 1971), the profile of the Raine Island beach platform causes the females in the beach depression to move approximately parallel to the water line for varying distances. Some may wander the entire length of the island in the beach depression before localised irregularities of topography lead them to the outer crest of the beach and hence to the water. The net result is to increase the time taken to return to the water. Turtles on the beach after daylight heat in the sun, leading to locomotory deterioration as hyperthermia progresses, then ultimately death ensues. Some of the turtles crossing the cliff line entered the central depression and some of these became disoriented and similarly wandered back and forth across the central depression into the daylight hours. These too died of heat exhaustion as the day progressed.

Nesting females remaining on the beach platform have been observed to die as early as 0930hr and all females that had remained on the beach after about 1000hr, carapace uppermost, were dead by approximately 1700hr. During December 1989, six females that remained on the open beach platform towards the middle of the day were selected for study of lethal hyperthermia. Experience had shown that all such turtles died within the current day. Each was fitted with a core body temperature probe and the temperature recorded at approximately half-hourly intervals for several hours (Fig. 17). The core body temperature increased from 35.8°C at 1040hr to as high as 40.4°C in one turtle at 1230hr. All turtles died when their core body temperatures exceeded 39°C. The time of death varied from 1230hr to 1640hr (mode = 1445hr). These temperatures contrast with the core body temperatures of nesting turtles on the beach at night, measured in eggs at the instant of oviposition, that ranged from 26.0°C in early November to 28.4-30.0°C in early December

TABLE 14. Core body temperature of nesting *Chelonia mydas* on Raine Island as indicated by the temperature of a freshly laid egg.

Date	Temperature (°C)			
	Freshly laid egg = core body temp.	Air	Water	Sand
Night time nesting turtles (2000-0200hr)				
5 Dec 77	29.8	27.4	27.0	28.0
6 Dec 77	29.6	27.2		28.0
7 Dec 77	29.2	27.2	27.8	28.0
1 Dec 78	28.4	26.2		27.2
30 Nov 79	26.0			27.0
2 Nov 79	26.0	26.5		26.0
6 Nov 79	26.0			26.00
2 Dec 89	30.0			
Early afternoon nesting turtle (1500hr)				
3 Dec 89	33.0			

(Table 14). A female that came ashore and nested in the heat of the early afternoon had a higher core body temperature of 33°C (Table 14). A turtle on the beach in the heat of the day has a dark carapace surface exposed to the sun and this absorbs solar radiation that can heat the turtle to lethal temperatures. The carcasses continued to heat post mortem as the day progressed. By 1500-1900hr the mean core body temperature, measured during autopsy, of turtles that had died earlier in the day was 41.4°C (SD = 2.77, range = 32.2-54.4, n = 96). For the 1997/98-2000/01 seasons there was a substantial reduction in the proportion of turtles dying from heat exhaustion (0-47%) (Table 13). This change is believed to be a direct consequence of the increased rainfall associated with these latter seasons (Fig. 7). With the overcast conditions and the cooling effect of rain, turtles were less likely to overheat and die.

Thus, those areas of the island that are surrounded by more elevated habitat can become traps that result in the turtles not moving directly seaward but wandering for extended distances. These disoriented turtles are at risk of dying from heat exhaustion if they are still on the island during the heat of the day. Similar disorientation and fatal hyperthermia have been reported for turtles stranded behind a mainland mangrove zone by a cyclone tidal surge (Limpus & Reed, 1985b).

Inverted turtles take longer to attain lethal levels of hyperthermia due to the reduced heat absorption of their pale coloured plastrons. Some turtles that have wandered into partly shaded areas have survived extended periods ashore however exposed parts of their bodies have been extensively sunburned (to the extent that scutes and underlying tissue peeled from their bodies). The turtles trapped in the deeper caves beneath the phosphatic limestone platform are not subjected to heat stress and probably die from dehydration.

NECROPSY RESULTS. All dead turtles examined by necropsy at Raine Island were adult female *C. mydas*. All were gravid females with enlarged mature follicles in their ovaries. All had recently formed corpora lutea in the ovaries consistent with having ovulated in the past 2-3 weeks. Some had oviducal eggs, all of which were of normal ovipositional shell thickness. Four eggs were removed from each of 7 freshly dead turtles, preserved in isotonic formalin within 2 hr of collection and examined for stage of embryonic development. All were at embryonic stage 6, (middle gastrulation) which is the normal ovipositional stage for *C. mydas* (Miller, 1985). It must be concluded that only females ready for oviposition come ashore at Raine Island.

The enlarged vitellogenic follicles of the ovaries of 2 freshly dead females were measured in early December 1988 (Fig. 19). There was a natural grouping of large yolked follicles that were approximately the size of the yolks of post ovipositional eggs. In both females these were distinct from the remaining follicles which were

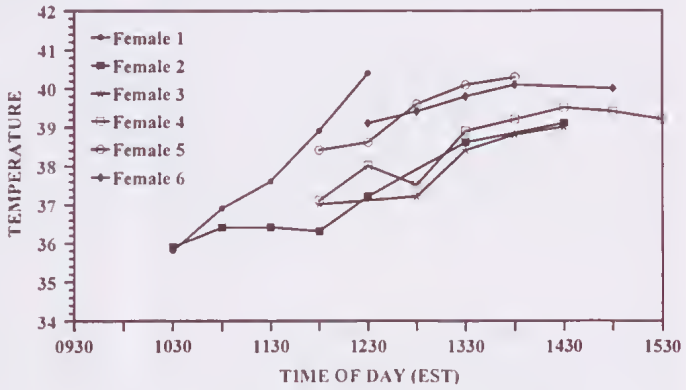

FIG. 18. Core body temperatures of moribund *Chelonia mydas* females that remained on the beach at Raine Island following nesting attempts during the previous night. EST denotes Easter Standard Time.

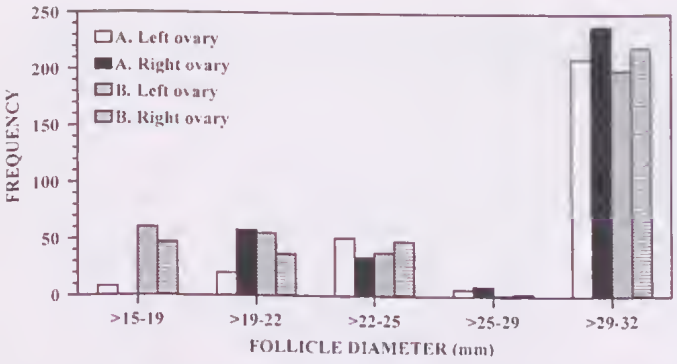

FIG. 19. Size distribution of yolked ovarian follicles in two *Chelonia mydas* females (A & B) that died of heat exhaustion after remaining on the beach at Raine Island following nesting attempts during the previous night.

smaller than normal yolks. This larger size class of yolked follicle is assumed to contain the mature follicles from which the successive clutches were to be produced by each female. Both of these turtles had complete clutches in their oviducts (clutch counts: A = 80, B = 100) from the previous ovulation and sufficient mature follicles in their ovaries for 4 or perhaps 5 additional clutches (mature follicle counts: A = 449, B = 420). These data suggest that by the beginning of the nesting season or very early within it, the female has pre-formed all the mature follicles she will require for the remainder of the season. If the number and/or weight of yolked follicles >25mm in diameter at the commencement of the migration from the feeding grounds, during courtship or as she arrives at the internesting habitat adjacent to the rookery could be quantified, it could provide a measure of the reproductive potential of the turtle without having to monitor it for months through an entire nesting season. The size of mature ovarian follicles and corpora lutea (Table 15) now forms the basis upon which determination of reproductive status of females captured in their feeding grounds are made.

Additional observations of oviducal eggs and ovaries in the necropsied turtles at Raine Island:

1984, 4-23 Dec: Shelled oviducal eggs were present in 66.2% of the dead turtles (SD = 16.21%, n = 12 daily samples totalling 310 turtles), regardless of the cause of death.

1986, 22 Nov-16 Dec: of 27 turtles necropsied, 2 (7%) had laid their entire clutch and 25 (93%) were carrying oviducal eggs.

1988, 29 Nov-8 Dec: All 4 turtles necropsied still retained what appeared to be complete clutches in their oviducts (clutch counts = 80, 100, 104, 113).

1989, 29 Nov-8 Dec: of 99 turtles necropsied, 47 (47%) had laid their entire clutch, 6 (6%) had laid only a portion of their clutch (8-33 eggs remaining in the oviducts), 46 (46%) retained what appeared to be complete clutches in the oviducts (mean clutch = 99.8, SD = 13.85, range = 66 - 127, n = 45). Rain during the first night increased nesting success of turtles for this period, of 8 freshly dead females examined on 8 December, 5 appeared to have begun atresia of almost all remaining mature follicles in the ovaries, even though each had sufficient large follicles for several more clutches. This prompted further examination of this issue in subsequent seasons.

1994, 29 Nov-10 Dec: of 39 females necropsied, mean oviducal egg count = 98.9 eggs (SD = 21.76, range = 34-160, n = 39).

1995, 5-13 Dec: of 22 females necropsied, 6 (27%) had laid their entire clutch while the remainder still contained oviducal eggs. At least 6 (27%) of the 22 sets of ovaries examined contained mature follicles that had begun atresia.

1997, 29 Nov-6 Dec: of 52 females necropsied, 8 (15%) had laid their entire clutch while the remainder still contained oviducal eggs. At least 38 (73%) of the 52 sets of ovaries examined contained mature follicles that had begun atresia.

1998, 1-9 Dec: The single female necropsied had no oviducal eggs and both ovaries had mature sized follicles that had begun atresia.

1999, 30 Nov-11 Dec: of 66 turtles necropsied, 26 (39%) had laid their entire clutch. The remainder carried 41-134 oviducal eggs consistent with having laid no eggs or having been disturbed by other turtles or by unsuitable nesting habitat after laying only part of a clutch. At least 38 (58%) of the sets of ovaries examined contained mature follicles that had begun atresia.

2001, 1-11 Dec: of 16 females necropsied, 9 (56%) had laid their entire clutch. The remainder carried oviducal eggs. Thirteen (81%) of the 16 sets of ovaries examined contained mature follicles that had begun atresia. The remaining 3 ovaries contained less than mature-sized follicles that had begun atresia.

These data demonstrate that while considerable variation existed (15-56%), few *C. mydas* that died at Raine Island had successfully laid an entire clutch during the previous night. The majority died while still carrying oviducal eggs: some died carrying reduced numbers of oviducal eggs, consistent with having been disturbed from a nest before a complete clutch was laid; and others appeared to be carrying complete clutches.

TABLE 15. Measurements of mature ovarian follicles and corpora lutea from adult female *Chelonia mydas* that died while ashore for nesting on Raine Island. The corpora lutea were selected from the largest size class, corresponding to the ovulation sites for the follicles represented in the oviducal eggs present in the turtles. The mature follicles were selected from among the largest size class of yolked follicles (Fig. 19). Each structure was measured along its greatest diameter.

Date	Measurement (mm)			
	Mean	SD	Range	n
Mature follicles				
1/12/78	31.1	1.22	29.3-33.5	20
17/12/85	33.2	1.04	31.4-34.9	10
Corpora lutea				
13/12/85	14.7	2.33	10.6-19.6	10
17/12/85	14.1	0.94	12.4-15.6	10

Substantial proportions (27-81%) of the adult female *C. mydas* attempting to breed in early December had already begun resorption of at least some of their mature ovarian follicles. In as much as early December is in the first half of the overall nesting season, these females would clearly not be converting all mature follicles to eggs.

SIZE OF DEAD TURTLES. The size of nesting *C. mydas* females that died on Raine Island is summarised in Table 16.

RESCUING MORIBUND TURTLES. During the research at Raine Island, the primary goal has been to document the functioning of the nesting population with the minimum of interference to it. In this regard it was not a goal to rescue dying turtles. However, in the normal course of the work, when live turtles were encountered that could be rescued easily, this was done. For example in December 1984, over 100 females were rescued. During the 1989-90 trip, 25 females were rescued. However in some years few turtles died, as in the 1985/86 season when only one was able to be rescued while five others died in the 27 nights the team was on the island during 24 November-20 December.

The simplest turtles to rescue were those on their backs that simply required righting. This could be accomplished by one strong person. If the cliff margin was patrolled daily at dawn, all turtles that had fallen on their backs during the previous night could be released before 0830hr. Turtles out on the open sand in daylight needed to be dragged to the beach crest. This normally required several persons working for more than

TABLE 16. Curved carapace length of adult female *Chelonia mydas* that died while ashore for nesting on Raine Island.

Year	Month	Curved carapace length (cm)			
		Mean	SD	Range	n
1976-77	Dec	106.7	4.19	99.5-117.5	23
1979-80	Dec	107.5	6.10	96.5-118.0	36
1981-82	Nov-Dec	106.0	5.12	90.0-122.0	84
1987-88	Nov-Dec	104.4	5.77	94.0-114.5	54
1988-89	Nov-Dec	102.5	4.42	95.0-109.0	13
1989-90	Nov-Dec	104.4	5.32	92.5-119.5	99
1991-92	Dead	104.1	4.618	94.4-110.0	48
1992-93	Dead	101.5		98.0-105.0	2
1993-94	Dead	104.1	4.97	89.0-115.8	53
1995-95	Dead	104.7	5.00	90.9-117.0	93
1996-97	Dec	104.1	4.59	89.6-120.7	379
1996-97	Jan-Feb	103.6	4.59	90.8-117.8	415
1996-97	Dead	103.9	4.59	89.6-120.7	800
1997-98	Dead	104.7	5.39	94.0-130.1	103
1998-99	Dead	103.9	4.17	97.8-113.8	12
1999-00	Nov-Dec	105.0	4.89	91.7-119.7	366
2000-01	Nov-Dec	106.0		96.6-112.9	3
2001-02	Nov-Dec	104.2	5.68	81.6-119.4	90

15 min per turtle, and was very strenuous work. It was debilitating to the research team to attempt to drag turtles across the open sand in the heat of the day. In high density nesting seasons there were often hundreds of turtles (sometimes over a thousand) on the beach as late as 0700hr. Most of these turtles successfully made it back to the water. It was usually after 0900hr before the turtles out on the open sand could be identified as threatened by heat exhaustion. Even at this time many of the turtles present still successfully made their way back to the water without assistance. However, by then it was also stressful for people to be working over this hot sand, so few turtles were rescued after 0900hr or before 1500hr.

If it were considered a priority to rescue moribund turtles at Raine Island the following summary points should be noted: only in high density nesting seasons will there be numerous nesting females dying on the island (most of the mortality will occur from mid November to about mid February); small numbers of moribund turtles can be rescued by righting those turtles which have fallen on their backs; most mortality occurs on the open beach as a result of heat exhaustion, not of turtles falling on their backs around the cliff; to rescue a large proportion of the moribund turtles would require a rescue team's daily presence on the island for months at mid season;

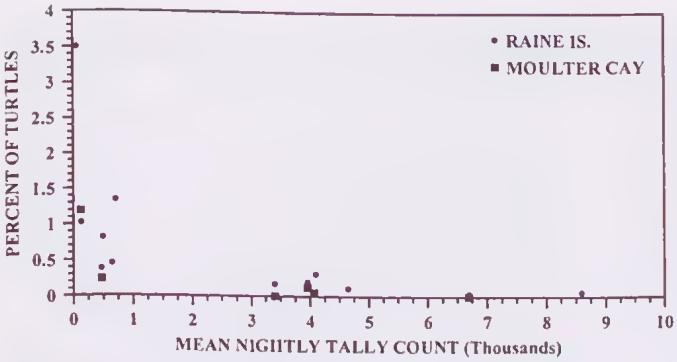

FIG. 20. Proportion of nesting female *Chelonia mydas* at Raine Island and Moulter with recent shark bites. Data sourced from Tables 3 & 17.

it is doubtful if most moribund turtles can be rescued daily in high density nesting seasons without some mechanical assistance.

SHARK PREDATION. During most summer visits large tiger sharks (*Galeocerdo cuvier*) were seen over the shallows of the reef flat and adjacent to the edge of the reef every day. Up to five individuals (judged by size) were seen in the one day at the western end of the island. Tiger sharks regularly were seen scavenging on the carcasses of turtles that had died while ashore at the beacon end of the island and then washed onto the reef flat by high tides. Less frequently they were observed to prey on live adult turtles. For example, in December 1986, a school of 5 tiger sharks attacked and killed an adult female *C. mydas* swimming over the reef flat adjacent to the island. Not all turtles attacked by tiger sharks are immediately killed. One female (X43893) had received a bite which removed a portion of her carapace over the right hind flipper to expose her abdominal cavity. Her intestine was undamaged but exposed. When she was seen nesting on 26 November 1982, the wound was healing and judged to have occurred at about the time of courtship. While she was nesting she had an open hole that permitted sand entry into her abdominal cavity. It did not appear to impede her nesting drive. The broad snout of the attacking shark (identified by tooth scars to the carapace) suggested that she had been attacked by a tiger shark. Observations such as this emphasise the impressive capacity of the large marine turtles to survive extensive injuries through shark attack. It also illustrates the extent to which the female will persist with her nesting drive in spite of debilitation and disturbance.

Each summer a small percentage of the nesting turtles had been recently mauled by sharks and the resulting wounds were still healing when the turtles were examined while nesting (Table 17). The degree of healing of the majority of the wounds indicated that they had probably occurred at, or just prior to, the commencement of nesting, possibly at courtship time. While some of these injuries had been caused by tiger sharks, others may have been caused by the medium to large whaler sharks (*Carcharhinus* spp.) that occur in the area.

Figure 20 illustrates the occurrence of fresh shark bites on the nesting turtles at Raine Island and Moulter Cay (Table 10) with respect to the size of the annual nesting population (December mean nightly tally count for Raine Island has been adopted as an index of population size; Table 3). There was a strong negative correlation between the size of the annual nesting population and the proportion of turtles recently bitten. This is further supported by the one small sample of nesting females examined in mid year 1987 when the nesting density was extremely low with less than 1 turtle/night ashore for nesting: 3 (43%) of the 7 nesting females examined had been recently mauled by sharks (Table 17).

The nesting turtles with fresh shark bite wounds represent the survivors (Table 11) — those that did not sustain a massive bite or a bite to a critical area. The actual mortality rate caused by shark bite of adult female *Chelonia mydas* at these rookeries remains unquantified. If the proportion of turtles surviving bites is positively correlated with the proportion of turtles in the population that are killed by shark attack, then these data suggest that there is a reverse density dependence between the risk of shark attack and the size of the annual nesting population. There is less risk if the turtle breeds in a high density nesting season. However, the risk of being mauled by a shark is highest for turtles that nest out side the main nesting season and for those that nest in low density nesting seasons. In addition it suggests that in the event of a substantial population decline, the remaining turtles would be at increased risk of shark attack when aggregated for breeding, assuming that the shark population remains stable and independent of the size of the nesting turtle population.

TABLE 17. Frequency of occurrence of recent shark bites on nesting *Chelonia mydas* at rookeries in the outer northern Great Barrier Reef.

Rookery & date	No. of turtles examined	Turtles with recent shark bites	
		n	%
Raine Island			
Dec 1980	284	10	3.5%
Nov-Dec 1982	1601	13	0.81%
Nov-Dec 1986	11032	22	0.20%
Jul-Aug 1987	7	3	43%
Nov-Dec 1987	2287	7	0.31%
Nov-Dec 1988	2391	32	1.34%
Nov-Dec 1993	11887	7	0.06%
Dec 1994	1346	6	0.45%
Dec 1995	4615	5	0.11%
Nov-Dec 1997	7122	2	0.03%
Nov-Dec 1998	3284	12	0.37%
Nov-Dec 1999	25283	10	0.04%
Dec 2000	756	8	1.06%
Nov-Dec 2001	9725	17	0.17%
Moulter Cay			
Dec 1986	2581	3	0.12%
Dec 1997	1956	1	0.05%
Dec 1998	427	1	0.23%
Dec 1999	844	0	0%
Dec 2000	84	1	1.19%
Dec 2001	873	0	0%
No.8 Sandbank			
Nov 1988	30	0	0%
Dec 1995	79	4	5%
Dec 1997	183	2	1.09%
No.7 Sandbank			
Dec 1986	74	0	0%
Nov 1988	26	0	0%
Dec 1995	73	0	0%
Dec 1997	108	0	0%

FLUCTUATIONS IN ANNUAL NESTING POPULATIONS

The most accurate method available at present to measure the size of a turtle nesting population requires a whole of season, total tagging census of the rookery (Limpus et al., 2001). At Raine Island this would require a nightly tagging census from early October to about April. In most years it would require numerous staff on the island for more than 3 months to ensure that every turtle ashore was accounted for without adding a major disturbance factor to the turtles. Such an approach has not been logistically or financially feasible to date, and would probably cause significant disturbance to the nesting sea birds. Tagging at Raine Island has been restricted to sampling a small portion of the total number of turtles nesting during any visit.

The *C. mydas* nesting in eastern Australia is confined essentially to a summer breeding season that reaches a peak period of nesting density during December and January (Raine Island: Table 4; Bramble Cay: Limpus et al., 2001; Heron Island: Moorehouse, 1933, Bustard, 1972.). At Raine Island the nesting season is more protracted than in the southern GBR, but it still maintains a mid summer peak of nesting density. It has been demonstrated that the average number of turtles ashore per night at a *C. caretta* rookery within a standard mid season sampling period can be used as an index of the total annual nesting population (Limpus, 1985). Turtle research at Raine Island has been timed to include a common annual sampling period in late November to early December. The mean nightly tally count during the last days of November and the first two weeks of December (Table 3) will be used as the index of the size of the annual nesting population for the purposes of the present study.

C. mydas nesting numbers have fluctuated widely from year to year at Raine Island and adjacent outer barrier reef cays (Tables 3-5). The annual fluctuations in the mean tally count for Raine Island in the two weeks of late November-early December is summarised in Fig. 21. In the mid-season of the very high density nesting years, many thousands of females come ashore nightly at Raine Island and Moulter Cay (Fig. 22). As many as 11565, 11467 and 14519 nesting females have been recorded on Raine Island in single walks of the beach (1974, 1984 and 1996 respectively) (Table 3, Fig. 23). These densities were equivalent to 6.4-8.1 females per metre of waterline for the island. In contrast, in a very low density nesting year, as few as 32 females on average have come ashore nightly (1977) (Table 3). This was equivalent to 1 turtle ashore per 56.3m of water line. The approximate synchrony in annual fluctuations in the size of the *C. mydas* nesting population encompasses the entire GBR. This is illustrated by the high level of synchrony of fluctuations in total annual nesting population at Heron Island in the southern GBR and the early December mean tally count at Raine Island (Fig. 21). These two rookeries have the most comprehensive census data recorded for *C. mydas* in Australia.

The historical records for Raine Island (see above) contain some useful indications of changing nesting population levels in past years.

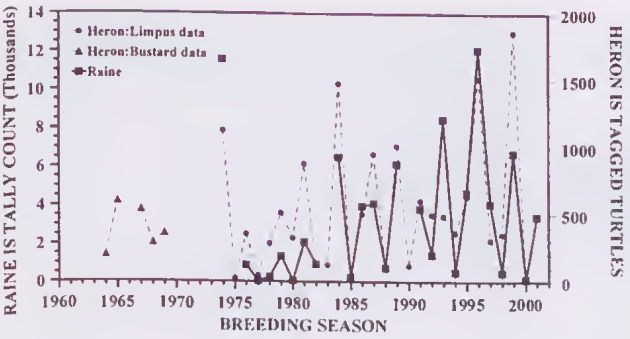

FIG. 21. Annual variation in *Chelonia mydas* nesting density at Raine Island and Heron Island. The mean tally count measured in the first two weeks of December (solid line) is used as an index of the size of the total nesting population. These data are derived from Table 3. The nesting season is denoted by the year it commences. The 1974/75 data were obtained from a single nights visit to the island on 29 November 1974.

The November 1973 estimate by Stoddart et al. (1981) of less than 200 females beaching per night at Raine Island suggests that 1973/74 was a poor nesting season. Whittaker estimated the mid season nesting at 'as many as 1500 turtles ... nightly' (breeding season not specified) when he applied in 1956 for a permit to harvest turtles from Raine Island. This estimate is of a similar magnitude as occurred during the 1979, 1981, 1982 and 1992 breeding seasons. Ellis (1936) described a scene consistent with up to a few thousand, rather than ten thousand, nesting females nightly at Raine Island during the 1890 to 1892 guano mining operation. In addition, there are several records consistent with extremely high turtle nesting density. MacGillivray (1917) described a scene with immense numbers of turtles in the shallows during the late afternoon on 4-11 December 1913 and further he complained of being 'tormented at night by the nesting turtles, who would persist in trying to walk over or under our sleeping shelter'. On 12 December 1913 he recorded on nearby Moulter Cay 'thousands of turtles climbing the sandbank' in the moonlight. Vlassoff (pers. comm.), estimated 10-12 thousand turtles ashore for the night during the 1955/56 season. While the accuracy of this estimate cannot be checked, his measure of about ten new turtles per night falling on their backs along the cliff line is consistent with a huge nesting population as is his photograph showing high density mortality in the central depression (Fig. 11). Similarly Watson's (pers. comm.) account of a breeding season in about 1965 when he stepped or jumped from turtle to turtle while Vlassoff walked 100 paces beside him in late November is consistent with nesting densities greater than those recorded in most recent seasons, except perhaps 1974/75, 1984/85 and 1996-97. In 1987 and 1999, Watson's method of measuring turtle nesting density was repeated at Raine Island and a stepping index recorded for nights with a range of nesting densities (Table 18). No more than 25 paces from turtle to turtle could be made when tally counts of up to 7,010 were recorded. From these considerations it concluded that the 1974/75, 1984/85 and 1996/97 seasons with very high nesting densities were not unique to recent years for Raine Island. Based on the historical data above and the recent quantified data (Tables 3-4) it is concluded that the annual nesting density of *C. mydas* at Raine Island has

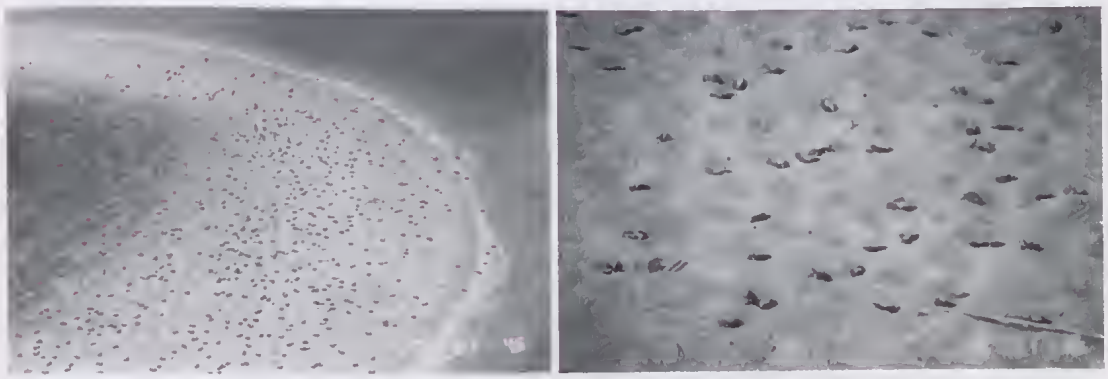

FIG. 22. Early morning oblique aerial photographs of Moulter Cay, 7 January 1990, showing high density nesting *Chelonia mydas*.

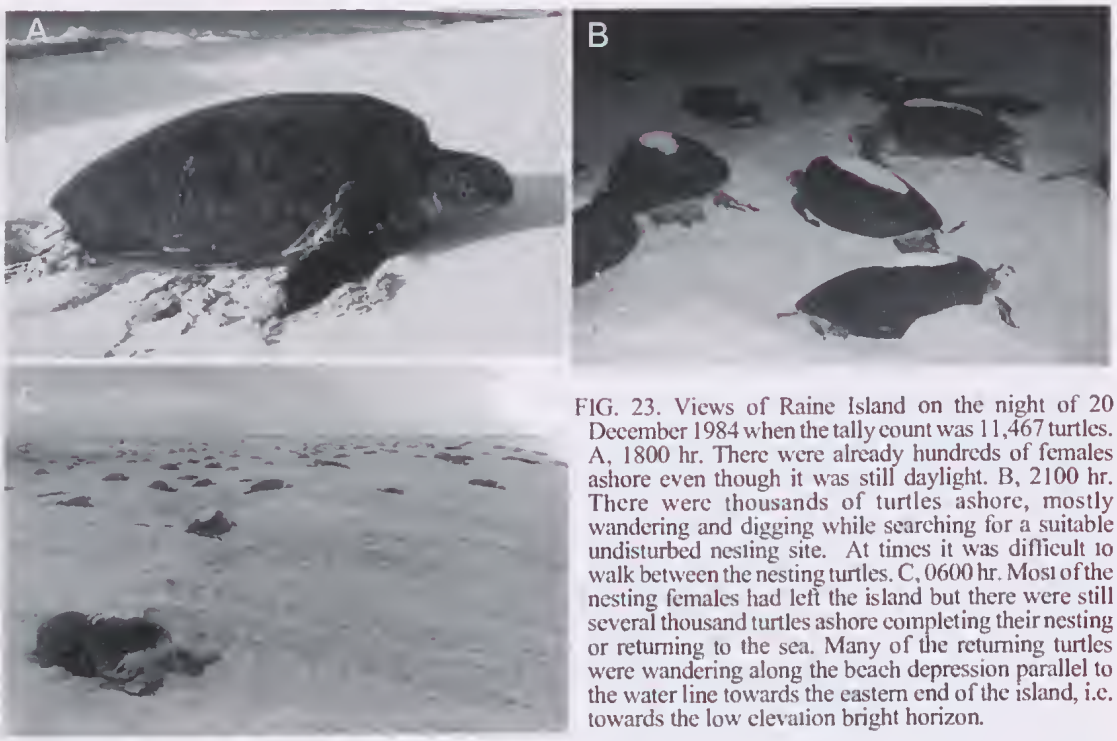

FIG. 23. Views of Raine Island on the night of 20 December 1984 when the tally count was 11,467 turtles. A, 1800 hr. There were already hundreds of females ashore even though it was still daylight. B, 2100 hr. There were thousands of turtles ashore, mostly wandering and digging while searching for a suitable undisturbed nesting site. At times it was difficult to walk between the nesting turtles. C, 0600 hr. Most of the nesting females had left the island but there were still several thousand turtles ashore completing their nesting or returning to the sea. Many of the returning turtles were wandering along the beach depression parallel to the water line towards the eastern end of the island, i.e. towards the low elevation bright horizon.

been fluctuating widely over several orders of magnitude for more than a century.

Limpus & Nicholls (1988, 1994, 2000) demonstrated that the number of *C. mydas* nesting on the eastern Australian rookeries in a given year is a function of the El Nino Southern Oscillation (ENSO) climatic events. The Southern Oscillation Index (SOI), the standardised difference in monthly mean atmospheric pressures between Darwin and Tahiti, is used as a measure of the variability of ENSO climate variation (Bureau of Meteorology Australia, 2002). In testing for the best correlation between breeding numbers and ENSO events, Limpus & Nicholls (2000) identified a significant correlation linked to the mean SOI value approximately 1.5yr before the breeding season commences. This time delay between the climate event and the onset of breeding is determined by the duration of the sequence of physiological processes that culminate in egg production. A female that commences laying eggs in November will have migrated from her distant foraging area approximately two months earlier. Before she commenced her breeding migration, she will have deposited yolk into the hundreds of mature ovarian follicles that she will use for egg production. This vitellogenic process commenced in about February and is completed by about September. Prior to commencement of vitellogenesis, the female will have increased her fat deposits during the previous months. This present study extends the analysis of Limpus & Nicholls (2000) using the more extensive eastern Australian *C. mydas* census data now available from 27 breeding seasons (Table 19). There continues to be a significant linear correlation between the mean May-October SOI approximately 1.5yr before the breeding season (MOSOI) and the natural log of the annual green turtle census data (census) from representative rookeries at each of the eastern Australian breeding aggregations (Fig. 24):

Raine Island:

$\ln(\text{census}) = -0.1178*\text{MOSOI} + 6.8949$ ($F_{1,22} = 19.48$, $p<0.001$; $r^2 = 0.4696$);

Heron Island:

$\ln(\text{census}) = -0.09243*\text{MOSOI} + 5.5755$ ($F_{1,25} = 29.89$ $p<0.001$; $r^2 = 0.5445$).

It is not unreasonalble that a slightly greater proportion of the variability in the number of breeding turtles is explained by the correlation for the Heron Island census. The use of a mid-season index of nesting numbers (Raine Island census) should show more variability than

TABLE 18. A comparison of the stepping index and the nightly tally count measure of *Chelonia mydas* nesting density at Raine Island.

Date	Stepping index (number of paces)			Tally count
	Mean	range	n	
30/11/87	3.5	3-5	4	3296
1/12/87	4.0	2-7	4	2312
2/12/87	4.2	3-6	5	4498
5/12/87	8.2	6-10	5	5011
28/11/99	4.7	4-5	3	5806
29/11/99	7.7	6-8	3	5834
2/12/99	20	15-25	2	7010
6/12/99	15	15	1	6745

a total season tagging census (Heron Island census).

Limpus & Nicholls (2000) have demonstrated that these fluctuations in the size of the annual *C. mydas* nesting populations result from variability in the proportion of adult females present in the distant foraging areas that prepared for breeding in any particular year. Because ENSO is a broad-scale regional climate event for the whole of the Southeast Asia-Western Pacific region, there is synchrony in fluctuations in the annual nesting populations at all *C. mydas* rookeries in the region, not only in eastern Australia but also throughout Southeast Asia (Limpus & Nicholls, 2000; Chaloupka, 2001). Therefore, the long-term census data for Raine Island and Heron Island represent significant baseline measures against which the size of nesting populations at other *C. mydas* rookeries in the Southeast Asia-Western Pacific Region can be compared.

The population census data recorded at Raine Island and Heron Island (Fig. 21) illustrate the difficulty of quantifying the stability of a *C. mydas* nesting population. In the absence of the 1974 data, the annual nesting populations at both these rookeries over a 15 yr period could be interpreted as increasing. However, an inclusion of the 1974 data negates that interpretation. There has been a higher frequency of high density nesting seasons since 1984 than in the ten preceding years. The stability of these *C. mydas* populations cannot be assessed by measuring the size of the annual nesting population over a few years or even over a decade. It will require several decades of detailed monitoring of the size of the nesting population before anything more subtle than catastrophic decline of numbers can be reliably demonstrated.

REPRODUCTIVE DISCRETENESS OF THE NORTHERN GREAT BARRIER REEF *CHELONIA MYDAS* NESTING AGGREGATIONS

Traditionally it has been assumed that marine turtles return to breed at the beach of their birth. However, there are sparse data on marine turtle growth from birth to adulthood to demonstrate the truth of this. There has been one good case history that provides circumstantial evidence that the major *C. mydas* rookery areas support non-interbreeding populations. The once large *C. mydas* population breeding at the Grand Cayman rookery of the Caribbean Sea was overharvested to approximate extinction during the 19th century and almost no *C. mydas* nesting has been recorded there in the 20th Century. However, the large Tortuguero *C. mydas* rookery of Caribbean Costa Rica (approximately 1,000 miles away from Grand Cayman) still functions at high nesting density (Groombridge & Luxmoore, 1989). Turtles born at the Tortuguero rookery have not been recruiting to breed on the Grand Cayman beaches.

Within Australia, Bustard (1972) postulated that the nesting populations of the separate cays of the Capricorn-Bunker Groups, southern GBR, were non-interbreeding groups. The management implications of this were that each island breeding unit could be managed independently of the others. However, movements of breeding turtles demonstrated by tagging-recapture studies of courting and nesting turtles (Limpus et al., 1984a, 1994b; Limpus, 1993) indicate that *C. mydas* cannot maintain non-interbreeding populations among a group of islands as closely spaced as those of the Capricorn-Bunker Groups. In addition, as a result of temperature dependent sex determination among marine turtles and the differences in beach temperatures, different sexes of hatchlings can be produced from different rookeries (Limpus et al., 1983c). This latter study suggested that the warmer rookeries of mainland south Queensland produce mostly female hatchling *Caretta caretta* while the cooler beaches of the adjacent coral cays of the Capricorn-Bunker Groups produced mostly male hatchlings. The entire assemblage of these rookeries probably represented a management unit comprising complementary rookeries for *Caretta caretta*.

PROTEIN ELECTROPHORESIS. Using an electrophoretic survey of presumptive protein loci, Gyuris & Limpus (1988) demonstrated that

TABLE 19. Annual census data for nesting green turtles, *Chelonia mydas*, at Heron Island representing the southern Great Barrier Reef nesting population and Raine Island representing the northern Great Barrier Reef nesting population. MOSOI denotes the mean May to October SOI (Bureau of Meteorology Australia, 2002) from approximately 1.5yr before the breeding season; ln denotes the natural logarithm. The Heron Island census data are derived from a tagging census of the total annual nesting population. The Raine Island census data are derived from the mean nightly tally count (number of nesting females counted in one walk of the island) for the first two weeks of December. These data are an extension of the data summarised in Limpus & Nicholls (2000).

SOI data		Breeding season	Turtle Data			
Year	MOSOI		Heron Island		Raine Island	
			census	ln(census)	census	ln(census)
1972	-13.6	1974	1121	7.02	-	-
1973	9.5	1975	21	3.04	-	-
1974	8.8	1976	355	5.87	872	6.77
1975	17.3	1977	46	3.83	32	3.47
1976	-5.4	1978	285	5.65	243	5.49
1977	-13.0	1979	513	6.24	1347	7.21
1978	4.0	1980	327	5.79	59	4.08
1979	-0.8	1981	878	6.78	2049	7.63
1980	-2.6	1982	139	4.93	925	6.83
1981	6.1	1983	125	4.83	-	-
1982	-18.8	1984	1471	7.29	6493	8.78
1983	1.6	1985	42	3.74	227	5.42
1984	-1.2	1986	505	6.22	3956	8.28
1985	-1.0	1987	947	6.85	4102	8.32
1986	-0.1	1988	111	4.71	731	6.59
1987	-15.2	1989	1009	6.92	6144	8.72
1988	11.2	1990	120	4.79	-	-
1989	6.4	1991	602	6.40	3828	8.25
1990	1.5	1992	498	6.21	1417	7.26
1991	-10.6	1993	488	6.19	8462	9.04
1992	-5.7	1994	370	5.91	500	6.21
1993	-11.7	1995	632	6.45	4647	8.44
1994	-15.0	1996	1509	7.32	12100	9.40
1995	-0.6	1997	289	5.67	4067	8.31
1996	6.28	1998	351	5.86	471	6.15
1997	-18.1	1999	1801	7.50	6693	8.81
1998	9.47	2000	26	3.26	129	4.86
1999	2.98	2001			3402	8.13

if reproductive isolation occurred among the *Caretta caretta* rookeries of the southern Great Barrier Reef then the isolation was between the rookeries of the Swain Reefs and those of the remainder of south Queensland. A similar study of eastern Australian *C. mydas* was attempted. Non-sibling *C. mydas* hatchlings from Raine Island and other eastern Australian rookeries were collected during the 1979/80 breeding season for a collaborative study of the population genetics of eastern Australian *C. mydas* with Commonwealth Scientific and Industrial Research Organisation staff (Cleveland Laboratory). The specimens were inadvertently destroyed at the laboratory before the study was completed and no results are available. During the 1982/83 breeding season 21 non-sibling *C. mydas* hatchlings were collected at Raine Island. Another sample of >50 non-sibling hatchlings collected from Raine Island in April 1984 was lost before analysis as the result of a freezer power failure. An electrophoretic survey of 27 presumptive protein loci was made of the available *C. mydas* hatchlings from Raine Island and a similar series collected from Heron Island (Gyuris, 1984). This study identified low genetic variability within the species but the results were insufficiently differing to reject the nul hypothesis of there being a single breeding population of *C. mydas* within the GBR. The low

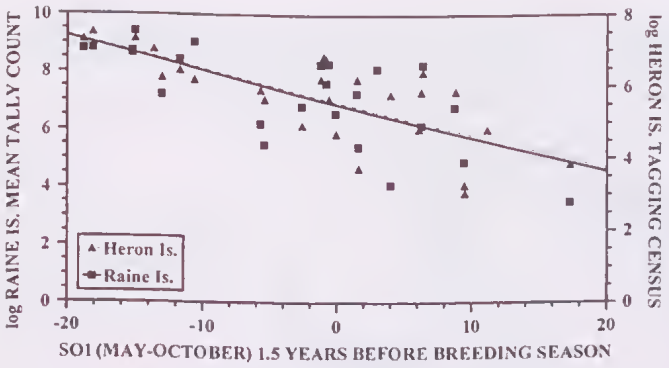

FIG. 24. Correlation of the natural logarithm of the annual census data recorded for northern and southern Great Barrier Reef *Chelonia mydas* populations and the mean May-October Southern Oscillation Index (SOI) approximately 1.5 years before the breeding season. Census data (Table 19): for Raine Island, annual mean tally count during the first two weeks of December; for Heron Island, annual total tagged nesting population. See text for regression equations and goodness of fit statistics.

levels of electrophoretic variability in sea turtles is such that it is not sensitive enough to deliniate reproductively isolated populations.

DNA ANALYSES. The application of mitochondrial DNA restriction analysis to Australian *C. mydas* nesting populations at Raine Island, Heron Island and Western Australia (Norman et al., 1994a) reinforced the studies of Bowen et al. (1989, 1992) and Meylan et al. (1990) that demonstrated that the nesting female returns to breed in the region of her birth. Norman et al. (1994a) further demonstrated that, while widely separated female breeding aggregations were genetically different, the nesting populations on nearby islands could not be discriminated. These results were subsequently corroborated by mtDNA sequencing studies and microsatellite nuclear DNA analysis by Norman et al. (1994b), FitzSimmons et al. (1995, 1997a) and Moritz et al. (2002). In particular, these studies have identified that there are three separate genetic stocks that breed in eastern Australia in the northern (nGBR), the southern GBR (sGBR) and the Coral Sea Platform (Fig. 13). Each of these stocks is also genetically separate from each of the other breeding aggregations tested from within the Indian Ocean and Pacific Ocean basins. Torres Strait is identified as a stock boundary with 100% genetic isolation occurring between *C. mydas* breeding at GBR rookeries and those of the Gulf of Carpentaria. The nGBR stock encompasses rookeries from Bramble Cay in northeast Torres Strait south to at least No.8 Sandbank which lies north of Princess Charlotte Bay, with the largest nesting aggregations centred at Raine Island and Moulter Cay. Each stock is characterised by a dominant haplotype and all show very low levels of within population variation. The dominant haplotypes of the nGBR and sGBR stocks are shared at low frequency by the other respective stock. This overlap in the distribution of the dominant nGBR and sGBR haplotypes indicates that a very low level of interbreeding by females could be occurring between the two stocks. In contrast there is no detectable female mediated gene flow between the east Australian and Gulf of Carpentaria-Western Australian stocks.

FitzSimmons et al. (1997b) compared the mtDNA haplotypes of breeding male *C. mydas* at three courtship areas (Raine Island Reef, nGBR; Heron Island Reef, sGBR; Bountiful Island, Gulf of Carpentaria) with mtDNA haplotypes from nesting females at the rookeries adjacent to each of these courtship areas. They found that breeding males were displaying comparable philopatry to the courtship area as the nesting females were to their nesting beaches. A comparison of rates of nuclear DNA gene flow (male and female mediated gene flow) and mtDNA gene flow (female mediated) among *C. mydas* rookeries located around the Australian coast (FitzSimmons et al., 1997a) identified that the estimated rates of gene flow between stocks were generally higher than expected for nuclear DNA relative to mtDNA. The difference was most pronounced between turtles from the nGBR and sGBR stocks. It was proposed that the atypical nuclear DNA difference between the nGBR and sGBR stocks was most likely the result of the geography of Torres Strait that caused a bottleneck for turtles migrating from the west. Some breeding females from the sGBR stock migrate from foraging areas in Arnhem Land and Gulf of Carpentaria through Torres Strait towards their traditional nesting area in the southern GBR. These sGBR females could be mated by males from the nGBR stock in the Torres Strait courtship area as the sGBR females pass through. Nuclear DNA gene flow could thus occur between the stocks even though both the males and females display comparable high

TABLE 20. The geographical distribution of foraging areas identified via tag recoveries of adult female *Chelonia mydas* recorded nesting at northern Great Barrier Reef rookeries. * Tag recoveries from Torres Strait could also include migrant turtles captured at courtship or turtles captured while migrating through the area.

Foraging area (Recapture location)	Rookery area					
	Northern GBR Stock					Southern GBR
	Eastern Torres Strait	Raine Is + Moulter Cay	No.7 & No.8 Sandbanks	Inner shelf, nth GBR	Total	
Indonesia	2	17			19	0
Arnhem Land & Gulf of Carpentaria	2	40	4		46	11
Torres Strait* (PNG+Qld)	17	215	6	1	239	15
Eastern & northern PNG	3	14	2	1	20	3
Vanuatu		1			1	0
Fiji					0	2
New Caledonia		2			2	31
GBR: Cape York to 14°S	3	60	1		64	24
GBR: 14-24°S	1	7	1		9	298
Qld >24°S		3			3	109
New South Wales					0	1
Total	28	359	14	2	403	494

levels of philopatry to their respective breeding areas (FitzSimmons et al., 1997b).

In summary, the assemblage of *C. mydas* that breeds at the rookeries and courtship areas of the northern GBR centred on Raine Island and Moulter Cay and the dispersed assemblage of these same turtles in their respective foraging areas represents a globally significant, single, independent management unit.

MIGRATION

Limpus et al. (1992) reported on breeding migrations from the eastern Australian *C. mydas* stocks. The sample size of migration recaptures of adult females from the northern GBR rookeries (n=403) has approximately doubled since that study. The current dataset is summarised in Table 20 & Fig. 25. Conclusions from this larger dataset are summarised.

Adult females from the nGBR stock migrate from foraging areas in eastern Indonesia, Papua New Guinea, Vanuatu, New Caledonia, Northern Territory and from throughout coastal Queensland to breed at rookeries within the northern GBR and Torres Strait. These foraging areas span a region 25° in latitude from southern Irian Jaya in Indonesia to Moreton Bay in south Queensland and 37° in longitude from Melville Island in western Northern Territory to southeastern New Caledonia. While the majority of recaptures have occurred within a few hundred kilometres of the rookery, the longest distance between rookery and capture site was 2,773km from Raine Island to Vanuatu.

The majority of the nGBR stock tag recoveries have been from north and west of the nesting beaches, from foraging areas in Torres Strait, Gulf of Carpentaria and coastal areas of the Arafura Sea in Irian Jaya and Northern Territory. The north-south distribution of foraging area tag recoveries from eastern Australia of adult females from each of the nGBR and sGBR stocks are summarised in Fig. 26. While there has not been equal sampling effort at each latitude, the nGBR stock is the dominant component of the foraging populations within eastern Australia to as far south as approximately latitude 13°S. South of this, the sGBR stock is dominant. These data indicate that adult females from stocks breeding at opposite ends of the GBR do not occupy identical feeding distributions.

Migration data are available for only one adult male. This resident from Shoalwater Bay (~22°20'S, 150°12'E) in Central Queensland was trawl captured in Torres Strait at courtship time.

Most (76.7%, n=310) of the reported nGBR *C. mydas* stock migration recaptures were of turtles hunted for food, 3.2% (n=13) were from incidental captures in commercial fisheries, mostly trawling, 15.8% (n=64) were captured during systematic sampling of feeding populations during Queensland Turtle Research projects and 2.2% (n=9) were from stranded dead or rescued turtles. The remaining 2.0% (n=8) of reports did not identify the capture method.

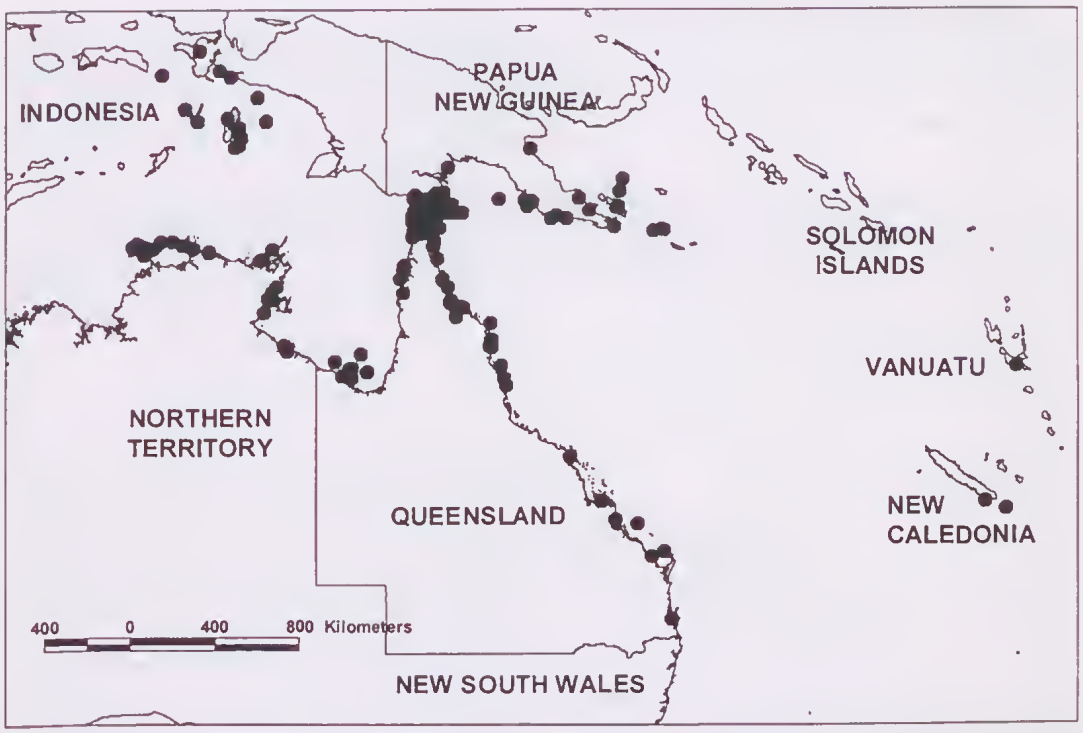

FIG. 25. Distribution of non-nesting recaptures of adult female *Chelonia mydas* that had been tagged at rookeries of the northern Great Barrier Reef stock: No.7 and No.8 Sandbanks, Raine Island, Moulter Cay and Bramble Cay.

In addition to these tag recoveries there have been other reports of tagged turtles for which the tags and/or the data were not returned. This is particularly so in neighbouring countries where there may be low levels of literacy or a poor capacity to read the English text of the tags. In remote areas, hunters may not be able to afford the postage to return tags. In some parts of northern Australia groups of tags have been found in homes of hunters, the tags having been retained as souvenirs of the hunting. In contrast, there is a belief among many of the turtle hunting communities of eastern Indonesia, PNG and some parts of northern Australia that the tag represents ownership of the turtle and that the hunter will 'get into trouble' for killing someone else's turtle if he reports the capturing of a tagged turtle. In the same area there also has been negative publicity concerning turtle hunting and tags are associated with bureaucratic interference in the hunting practices. In these latter cases the tags are apparently often discarded. These reasons may account for the recent paucity of tag returns from Indonesia even though there was a substantial increase in *C. mydas* hunting for the Bali market in the Aru and Irian Jaya areas since about 1988 (J. Schulz and I. Suwelo, pers. comm., Nov. 1990) until the 2001 closure of the Bali turtle trade (W. Adnyana, pers. comm., May 2002). This shift in hunting effort probably was in response to the substantial decreases in *C. mydas* populations in other parts of Indonesia (Groombridge & Luxmoore, 1989).

There are some general principles for *C. mydas* breeding migrations that can be drawn from these data.

1) The individual adult female has a strong site fidelity to her traditional nesting beach (Table 7). However, the present study has not demonstrated clearly the corresponding fidelity of the female to her particular feeding area as has been demonstrated for the females migrating to breed at the southern GBR *C. mydas* rookeries (Limpus et al., 1992). With most post-nesting migration recaptures from the northern GBR rookeries having been derived from turtles hunted for food, there was a reduced potential for recording turtles over successive legs of their migration between foraging and nesting areas to establish foraging area fidelity.

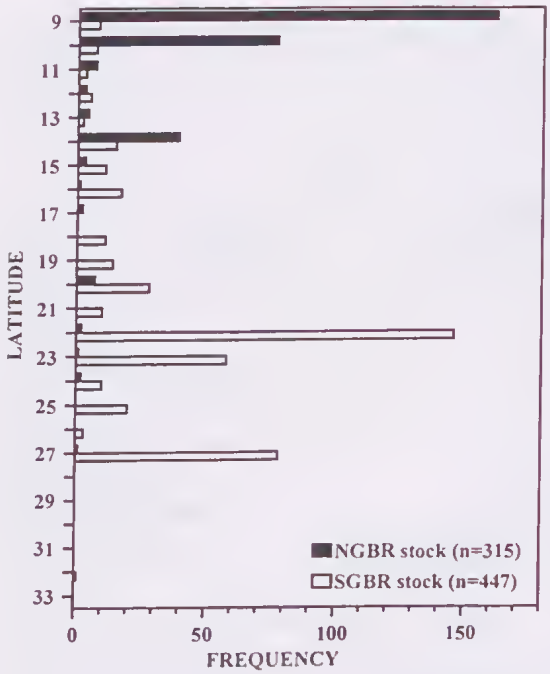

FIG. 26. Comparison of frequency distributions of captures in eastern Australian foraging areas south from the Papua New Guinea coast of Torres Strait of adult female *Chelonia mydas* recorded on nesting beaches of the northern and southern GBR stocks. Recaptures grouped by 1° latitudinal blocks.

2) Adult females that breed at the same rookery do not all migrate from the same foraging area (Table 20).

3) Breeding females did not necessarily nest at the closest rookery to their respective foraging areas. For example, X10925 was tagged at Raine Island, stranded 1,057km away by cyclone Kathy in the MacArthur River delta 3 yr later was rescued, then again recorded nesting at Raine Island after a 4yr remigration interval (Limpus & Reed, 1985b). She did not go to the Wellesley Group rookeries of the southern Gulf of Carpentaria or the eastern Arnhem Land rookeries that were closer to her feeding area. This also applies for all recaptured turtles from the Northern Territory. Similarly, not all the females that lived on the reefs of the far northern GBR migrated to the adjacent Raine Island and Moulter Cay rookeries. Some migrated past Raine Island to breed in the southern GBR.

4) Females living in the same foraging area do not all nest at the same rookery (Table 20).

5) Turtles in foraging areas represent populations of mixed genetic stocks. For example, in addition to those that breed at nGBR rookeries, female *C. mydas* foraging in the Princess Charlotte Bay area in the northern GBR have been recorded breeding at rookeries in the Coral Sea Platform, the southern GBR and internationally in eastern Papua New Guinea, eastern Solomon Islands, and northern New Caledonia. In an extreme case, adult female *C. mydas* captured off Coburg in the Northern Territory, have been recorded nesting at Raine Island, at Western Australian rookeries and in southeastern Java, Indonesia.

REMIGRATION

Remigration, the interval between breeding seasons, varies between species and has posed a problem for measurement because of the long remigration intervals. The main problems have resulted from tag loss and the logistics of systematically monitoring a rookery for many years. Early research on marine turtle reproductive ecology did not rigorously address tag loss. In 1974 the Queensland Turtle Research Project was requested to take over the *C. mydas* field studies at Heron Island that had lapsed following the departure of Dr H.R. Bustard from Australia. The methodologies of the original project were initially retained, in particular the tagging methodology of applying a monel tag to the L1 tagging position (Bustard, 1966). Within a few years it was apparent that there was a significant tag loss problem within this study. In 1978 systematic studies were commenced to identify the optimal position for tag application and to find a tag that had low rates of loss over a 10 yr development. These studies identified the need for a new design of turtle tag that used a metal with very low corrosion rates, and that was at a reasonable cost. Titanium and inconel 625 were identified as the preferred metal types. Within the Queensland Turtle Research Project, we were able to locate a tag manufacturer prepared to produce turtle tags from titanium. In a parallel study in Hawaii, G. Balazs worked with an American manufacturer to produce a turtle tag from inconel 625. The tag trial studies (Limpus, 1992a) demonstrated that the optimal tagging position is in the axillary area on the trailing edge of the front flipper (L3 or R3 tagging positions). The more distally the tag is applied, the more likely it is to be lost. Monel tags have a high probability of tag loss, approaching 100% in 10 yr. Plastic tags did not perform better than the monel tags in the long term. Titanium tags were

TABLE 21. Frequency distribution of remigration reeaptures of nesting female *Chelonia mydas* reeorded by tagging year eohorts at Raine Island since the commencement of Raine Island Corporation funded research and monitoring. The summer breeding season is defined by the year at the commeneement of the breeding season. Tag type definitions follow the tag design definitions of Limpus (1992a): M, monel tags; T, titanium tags. Slight variations in design of the titanium tags are denoted by T1, T2, T3 and T4. However, the variation in the design of the titanium tag is not included in the analysis of this study.

Census for recovery of tags		Breeding season for commencement of cohorts originally tagged while nesting at Raine island																					
Year		1981	1982	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	No. tagged turtles	2605	1094	504	80	2545	1919	1717	1559	1952	1037	1208	1368	1999	1593	1034	1668	2997	1434	1982	2210	840	1417
	Tag type	M2	M2	T1	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T3	T3	T4	T4	T4	T4	T4	T4	T4
1981																							
1982		0																					
1983	No RIC survey	22	1	0																			
1984		16	8	1	0																		
1985		43	22	5	1	0																	
1986		9	5	14	2	2	0																
1987		1	2	17	2	9	0	1															
1988		0	0	1	1	34	23	1	0														
1989		40	0	2	0	138	92	29	0	0													
1990	No RIC survey	2	7	0	0	27	25	51	40	3	0												
1991		2	0	0	2	37	11	29	39	86	0	0											
1992		0	1	2	0	12	13	5	27	72	2	0	0										
1993		0	3	3	0	38	12	12	40	53	22	6	0	0									
1994	No RIC survey	0	0	0	0	8	1	1	7	3	1	6	2	0	0								
1995		1	0	1	0	18	2	6	12	23	16	31	23	4	0	0							
1996	2 (Dec+Feb) surveys	0	0	2	1	42	13	18	33	42	42	40	56	74	23	0	0						
1997		0	0	5	0	33	13	9	26	45	22	44	39	84	57	13	0	0					
1998		0	0	1	0	14	2	2	7	24	6	17	9	31	28	13	3	0	0				
1999		0	0	0	0	57	7	21	46	56	43	61	67	114	176	74	115	32	1	0			
2000		0	0	0	0	2	5	0	2	7	2	2	5	11	5	12	3	11	6	0	0		
2001		0	0	3	3	23	3	8	17	17	16	18	25	41	31	21	59	108	53	12	0	0	
Remigrant : Cumulative total		136	49	57	12	494	222	193	296	431	172	225	226	359	320	133	180	151	60	12	0	0	

found to have at least a 50% lower rate of tag loss within the 6 yr period that titanium tags had been under trial. The experimental studies on tag retention were eonducted in the southern GBR where it was logistieally easier and less expensive to make repetitive eaptures of the same turtles over many years. As improvements in tagging methodology have been developed they have been applied to the nGBR studies.

REMIGRATION TAG RECOVERIES. The number of remigration reeaptures during eaeh study trip are summarised in Tables 7-9. There have been 3,727 remigrant reeaptures of turtles still wearing a tag up until the end of the 2001-2002 breeding season at Raine Island and adjaeent rookeries. These are not all of the tagged remigrants that have returned to these islands as there has been no examination of the entire nesting population in any one season, nor has the entire nesting population been tagged in any one season. The vast majority (98%, n=3,659) of remigrant reeaptures were reeorded at the same rookery at whieh eaeh turtle was originally tagged (Tables 7-9). Of the 33,234 females originally tagged at Raine Island prior to 2001, one has been reeaptured nesting at Bramble Cay and 21 at Moulter Cay. This very low rate of interseason ehange of rookery will be partly the result of the low sampling rate at nGBR rookeries other than Raine Island. However, of the 2,992 females tagged on the other outer eays of the northern Great Barrier Reef prior to 2001, only 1.2% (n=37) have been reeaptured nesting at Raine Island in a later season: 16 from Moulter Cay, 10 from No.8 Sandbank, 7 from No.7 Sandbank and 4 from Milman Island. In addition, one from No.7 Sandbank and two from Milman Island ehanged rookeries between breeding seasons to nest at Moulter Cay; three from No.8 Sandbank ehanged to No.7 Sandbank and one from No.7 Sandbank ehanged to No.8 Sandbank.

There has been eonsiderable tagging of *C. mydas* at other Australian rookeries in the southern GBR, Coral Sea region and the Wellesley Group in southeastern Gulf of Carpentaria sinee 1974. Only one of the approximately 40,000 female *C. mydas*, tagged while nesting in the southern GBR prior to the 2001/2002 season, was reeaptured nesting at any northern GBR rookery (Tables 7-9), although there have been many thousands of remigration reeaptures of southern GBR nesting females returning to nest in the southern GBR rookeries in later seasons (C. Limpus, unpubl. data). Similarly, only one nesting female from the QPWS and Environment Australia Studies at the Coral Sea Platform rookeries has been reeaptured

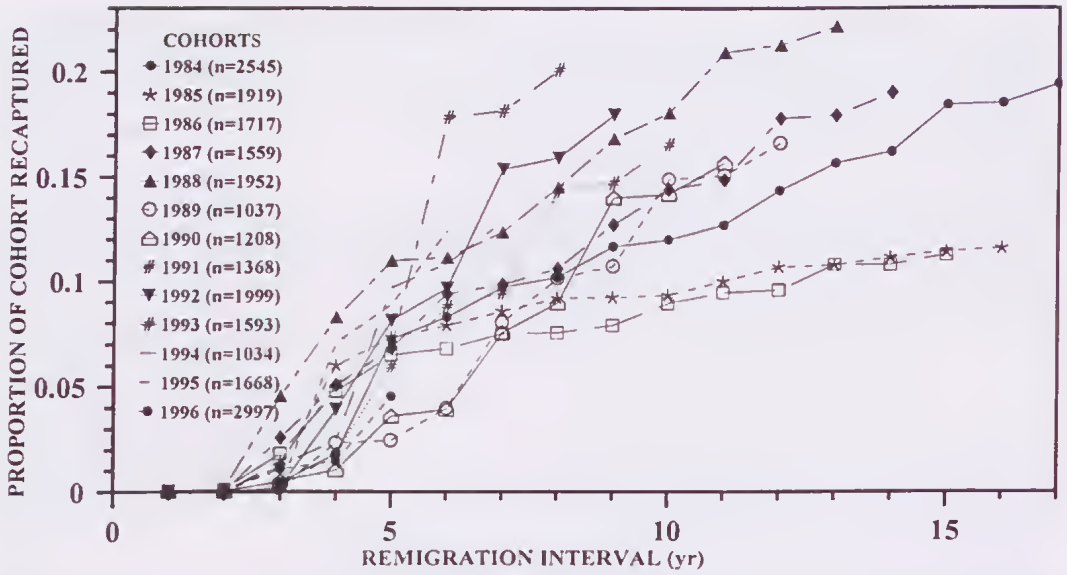

FIG. 27. Cumulative recapture rate of remigrant adult female *Chelonia mydas* at northern GBR rookeries recorded by the yearly tagging cohorts at Raine Island. Data are presented for the yearly tagging cohorts for which titanium tags were applied from 1984 until 1996.

breeding at Raine Island. None of the females tagged while nesting at the northern GBR rookeries have been recaptured nesting at the more intensively studied southern GBR rookeries. None of the more than 1,000 nesting *C. mydas* tagged nesting at Bramble Cay by Applied Ecology Pty Ltd in 1974 to 1980 has been recaptured nesting at Raine Island. No female *C. mydas* tagged nesting at an eastern Australian rookery has been recaptured nesting at a rookery outside of eastern Australia or vice versa.

Collectively, these data demonstrate that an adult female *C. mydas* exhibits a high level of fidelity to a particular nesting beach and can return to that same nesting beach even after migrating large distances to home feeding areas in the intervening years (Limpus et al., 1992). These observed rates of movements of breeding females among rookeries are reinforced by the results of DNA genetic analyses of *C. mydas* breeding populations of the Indo-Pacific Region (Moritz et al., 2002) that demonstrate a genetic interchange among adjacent rookeries such as those of the northern GBR and Torres Strait. At the same time, there is very little genetic interchange between the rookery regions of the north and south of the GBR (Norman et al., 1994a) or between rookeries of the nGBR stock and those much further away (Norman et al., 1994a; Moritz et al., 2002). The remigration tag recovery data are consistent with the genetic data in identifying groupings of *C. mydas* rookeries that support an interbreeding population separated from more distant breeding aggregations with which they do not interbreed.

RECAPTURE RATE OF REMIGRANTS. The remigration recaptures at Raine Island, uncorrected for tag loss, are summarised according to the breeding season in which they were tagged in Table 21 along with a summary of the tagging methodology used with each tagging year class. Less than 1% recapture rates resulted from tagging with monel tags applied in the L1 or R1 positions. The change to tagging in the L3 position improved the recovery of monel tagged turtles by a factor of approximately 5 to 10 times. The change to L3 applied titanium tags has more than doubled the rate of recovery over that of L3 applied monel tags (Table 22). Currently, the sampling of the Raine Island nesting population for approximately 2 weeks in early December each year is yielding a recovery of titanium tagged remigrants equivalent to 12-22% of the turtles originally tagged in the cohort (Fig. 27). These recovery rates continue to improve as additional sampling continues. In 2001 there were still recoveries being made from all year classes of titanium tagged turtles including 23 remigrants from the 1984/1985 season (17 yr since first tagged) (Table 21). There were even

TABLE 22. Frequency distribution of remigration from various year classes pooled by tag design. M1 and M2 denote different designs of monel tags (National Band and Tag Co. #49 and #19 respectively); T1 and T2 denote titanium tag designs as described by Limpus (1992a).

	Breeding season		
	1979/1980 + 1980/1981	1981/1982 + 1982/1983	1982/1983 + 1983/1984
No. tagged in cohort	2053	3696	584
Tag design	M1	M2	T1 & T2
Tag position	L3	L3	L3
Remigration interval	Frequency	Frequency	Frequency
1 yr	0	0	0
2 yr	0	1	2
3 yr	4	30	7
4 yr	9	38	16
5yr	23	48	18
6 yr	2	10	3
7 yr	5	3	3
8 yr	2	3	
9 yr	1		
Total	46	133	49
Proportion recaptured	2.2%	3.6%	8.4%

TABLE 23. Regression equations (in the form y = ax + b) for transformation from curved carapace length (CCL, cm) to other carapace measurements (cm) for breeding *Chelonia mydas* at Raine Island. * = not significant.

x	Y	a	b	r^2	n	P
Female						
CCL	Curved carapace width	0.776	14.469	0.769	504	<0.001
CCL	Straight carapace length (SCL)	0.983	3.356	0.997	54	<0.001
CCL	Carr's straight carapace length (CSCL)	0.787	16.243	0.963	29	<0.001
SCL	Straight carapace width (SCW)	0.494	26.733	0.575	54	0.02>p >0.01
Male						
CCL	Curved carapace width	0.735	16.272	0.703	25	0.01>p >0.005
CCL	Straight carapace length	0.771	17.613	0.967	25	<0.001
CCL	Carr's straight carapace length	0.799	15.516	0.937	14	<0.001
SCL	Straight carapace width	0.540	20.681	0.569	24	0.2>p >0.1*

three turtles recorded for the first time since they were tagged in 1982/1983 when titanium tags were first deployed. These extremely long intervals between captures probably represent multiple remigration intervals, given incomplete annual censusing. The tag recovery rate would improve if the sampling period at the island each summer was increased in duration.

In the December 1986 sample there were 2.2 times as many tag-scarred remigrants as there were remigrants with tags. During the December 1988 sampling period (6 yr after introduction of titanium tags) when many hundreds of nesting females were examined for tags each night, tagged remigrants were recorded at the rate of 2.0% of the nesting females examined (SD = 0.888, range = 0-2.55%, n = 9 nights). Remigrants that had lost their tags were recognised at an equal rate (mean = 2.0%, SD = 1.49, range = 0-3.95%, n = 9 nights). Most of these tag-scarred turtles are probably from the monel tagging years. By the December 2001 sampling (19 yr after introduction of titanium tags), tagged remigrants were recorded at the rate of 5.07% of the nesting females examined (SD = 1.996, range = 3.012-10.030%, n = 10 nights). Remigrants with lost tags were recorded at a rate that was an order of magnitude lower (mean = 0.79%, SD = 0.419, range = 0.149-1.399%, n = 10 nights). Large numbers of nesting turtles at Raine Island need to be examined on a nightly basis to ensure good sample sizes for remigration tag recoveries.

REMIGRATION INTERVAL. The frequency distribution of recaptures, uncorrected for tag loss, of remigrant *C. mydas* at Raine Island by tagging cohort and year of recapture are summarised for all years since the commencement of the Raine Island Corporation funded research in 1981 (Table 21). The usual method for presenting remigration data summarises the remigration interval recorded at a rookery within the year of recapture (Limpus et al., 1994b). While this method has value when considering events associated with the immediate breeding season, it confounds nesting season and tagging cohort effects. To enhance understanding of population dynamics, an analysis of remigration interval by tagging cohorts is more appropriate. Because the consecutive annual tagging cohorts have differing durations over which remigrants are recorded, an analysis of the raw data from each cohort (Table 21) would introduce a bias from the longer studied cohorts. The following considerations have been taken into account in choosing an interval for comparison

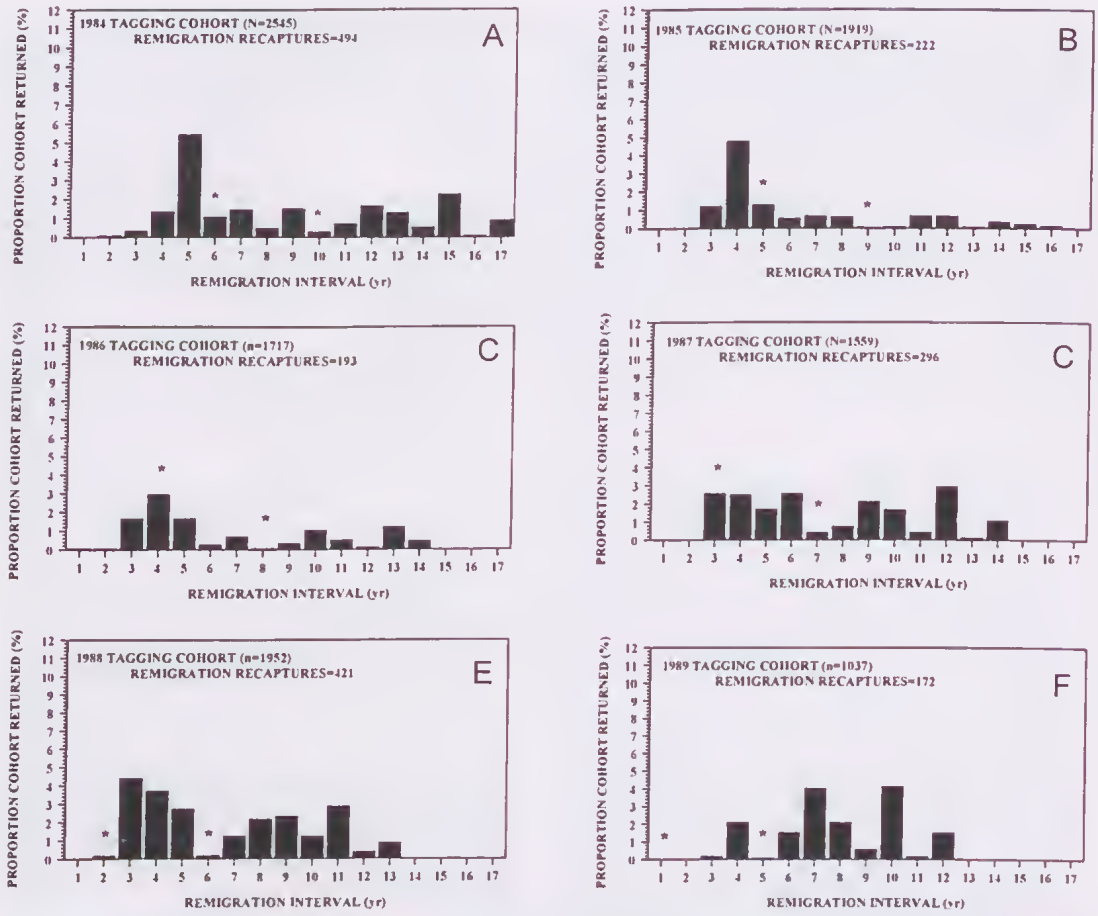

FIG. 28. Frequency distribution for remigration interval recorded from yearly cohorts of adult female *Chelonia mydas* tagged nesting at Raine Island since the introduction of large scale use of titanium tags, 1984-1997 (Table 21). * denotes an incomplete sampling year when no Raine Island Corporation survey trip occurred.

between cohorts. Bustard (1976) recorded no 2yr or 3yr remigration intervals during a major part of his nine consecutive years of total tagging census, commencing in.1964/1965, of the Heron Island *C. mydas* population (single monel tagging in L1 position). The Applied Ecology project at Bramble Cay recorded no remigration recaptures from four consecutive years of total tagging census of the *C. mydas* population during 1976/1977-1979/1980 (double monel tagging in L1 and R1 positions. Limpus et al., 2001). Based on long term titanium tagging, Limpus et al. (1994a) recorded that the majority of the *C. mydas* remigrants at Heron Island returned after 5-8 yr intervals. These studies indicate that the eastern Australian *C. mydas* stocks may not be breeding on the usually hypothesised 2-3 yr remigration interval for the species (Hirth, 1997). Because of the incomplete annual sampling of the nesting population at Raine Island, the longer recorded remigration intervals may be confounded by recaptures of turtles that had actually remigrated in intervening years but had not been recorded. The majority of the remigration intervals for the Raine Island *C. mydas* population were within 4-6yr (Table 21). Most tagging cohorts show a reduction in remigration recapture rate at about eight years (Fig. 27). Therefore the results from the 10 consecutive years of large scale titanium tagging at Raine Island during 1984-1993 will be analysed for remigration interval using only recaptures at less than nine years following first tagging or the last recorded breeding for a recaptured turtle. It is expected that restricting the analysis of the first eight years of remigration data for each cohort will minimise the number of multiple cycles that are mistakenly

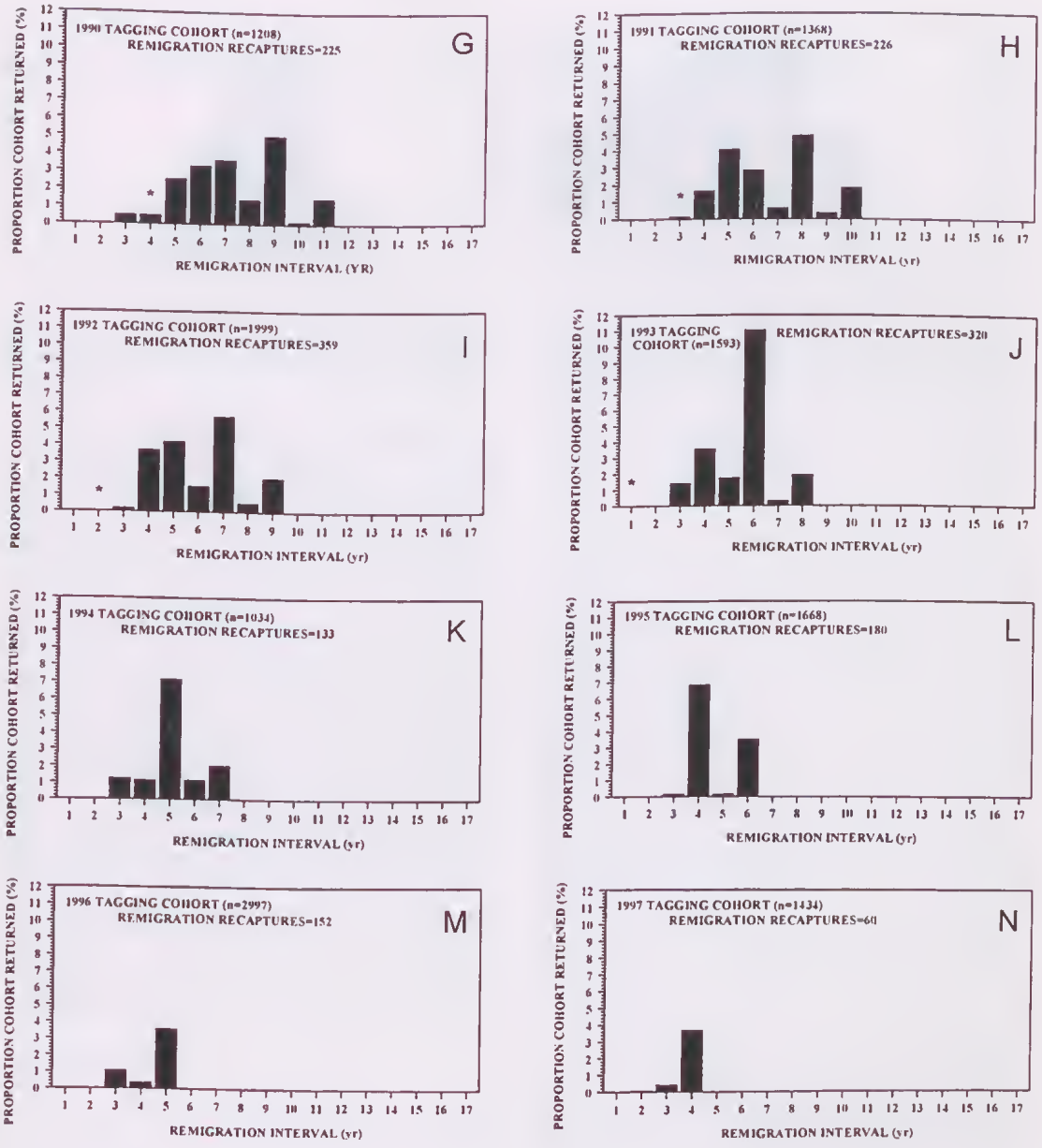

FIG. 28 (*Cont.*)

included in the analysis, while capturing the majority of the remigrations for the cohort.

It should be noted that the quantification of remigration interval at Raine Island has been partly compromised by the lack of continuity of sampling effort. The standard December sampling trips were not run in some years: 1983, 1990, 1994. The impact of reduced numbers of recaptures resulting from not checking large numbers of turtles for tags in these years can be tracked through the sequential remigration frequencies for each cohort (Fig. 28). Each cohort was impacted at a different remigration interval. For the combined 10 years of data from 1984 to 1993, some of these resulting between-year differences are expected to be smoothed.

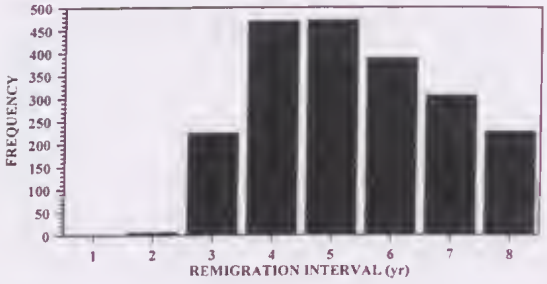

FIG. 29. Frequency distribution of remigration interval for adult female *Chelonia mydas* recorded at northern GBR rookeries pooled for ten annual tagging cohorts, 1984-1993. To minimise the confounding effect of varying durations of study period for the cohorts, only remigration recaptures spanning <9 yr have been considered. To minimise the confounding effect of tag design, only titanium tagged cohorts have been included.

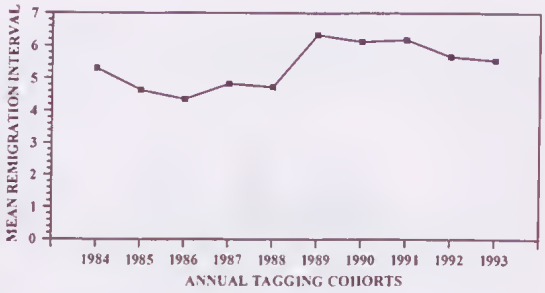

FIG. 30. Variability in mean remigration interval measured for 10 consecutive annual tagging cohorts of adult female *Chelonia mydas* nesting at Raine Island: 1984 - 1993.

At Raine Island, short remigration intervals of one and two years were extremely rare (0.33% from a sample of 2,094 turtles) (Fig. 29). Three year remigration intervals accounted for only 10.7% of recaptures. The modal remigration interval for the Raine Island *C. mydas* population was 4-5yr (Fig. 29). There are significant differences in annual remigration intervals among the annual tagged cohort from 1984 to1993 (one way ANOVA: $F_{9,2084} = 42.02$; $p<0.001$). No explanation is offered for the abrupt increase in mean remigration interval between the 1988 and 1989 cohorts (Fig. 30). While some of the differences may be attributable to the lack of continuity of sampling (Fig. 28), many of the differences appear to result from stochastic variability in the modal return interval among cohorts. When a strong positive SOI results in very depressed nesting numbers in a particular season, it limits the number of remigrants available for capture in that season. For example, during the extremely low density 2000/2001 nesting season, the remigration group corresponding to that in 2000 was very depleted within each cohort's recaptures (Fig. 28). However, a different remigration interval was impacted for each tagging cohort. In contrast, with high density nesting seasons such as 1999/2000, the remigration groups corresponding to those in 1999 were atypically high for their respective tagging cohorts (Fig. 28). It is apparent that there is no fixed remigration interval that applies for this stock. Remigration interval is variable in a complex response to regional climate fluctuations.

To further investigate remigration variability from the perspective of the breeding season of recapture, the remigration data (Table 21) was reanalysed with respect to the year of recapture (breeding season) within the 11 seasons 1991-2001 (Fig. 31). Again, the analysis was restricted to the remigration intervals <9 yr. Remigration intervals analysed from this period encompass returns from the years since the introduction of titanium tagging of the Raine Island nesting population in 1983. A reasonable comparison cannot be easily made with data originating from the earlier years when turtles were tagged with monel tags, given the high rate of tag loss for monel tags (Limpus, 1992a). There were significant differences in remigration interval by nesting season of recapture for the years 1991-2001 (1 way ANOVA: $F_{10,2146} = 15.65$; $p<0.001$). In addition there was a significant linear correlation between the mean remigration interval and the year:

Remigration interval = 0.08364*year − 161.5452
($F_{1,9} = 8.30$, $0.01<p<0.025$. $r^2 = 0.48$, DF = 9).

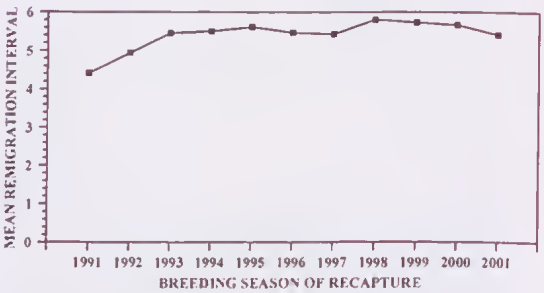

FIG. 31. Variability in mean remigration interval measured within 11 consecutive breeding seasons for adult female *Chelonia mydas* nesting at Raine Island: 1991 - 2001.

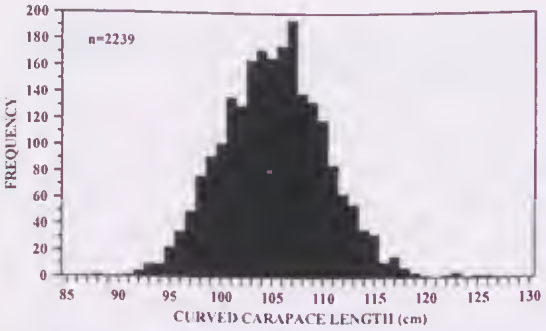

FIG. 32. Frequency distribution of size of nesting female *Chelonia mydas* recorded at Raine Island and Moulter Cay during the 1999-2000 breeding season.

Mean remigration interval has increased over at least the past decade (Fig. 31).

No significant linear correlation was found between the mean annual remigration interval measured within the breeding season of recapture and the mean May-October SOI measured 1.5 yr before the breeding season ($F_{1,9}=0.007$, $p>0.25$).

SIZE OF BREEDING ADULTS

FEMALES. A comparison of several methods of measuring turtle size is shown (Table 23). Because CCL has been the standard length measurement of marine turtles used in Australia (Bustard, 1972; Limpus & Walters, 1980; Limpus, 1980b; Limpus et al., 1983a,b) and South Africa (Hughes, 1974a,b) and because of the high correlation between CCL and the two other length measurements in common use (Carr's straight carapace length: Carr & Ogren, 1960; Straight Carapace length: Hughes, 1974a,b), CCL will continue as the standard length measurement for this study. Should the need arise for comparison with overseas studies, CCL can be transformed to other required lengths using the equations of Table 23.

The carapace measurements of nesting females are summarised in Tables 24-26 and Fig. 32. Averaged over the 25 seasons of sampling in November - December at Raine Island, the mean female CCL = 105.97cm (SD = 5.142, range = 86.0 - 130.1, n = 20947. Table 24). Averaged over 6 of these seasons, mean female CCW = 98.1cm (SD = 5.04, range = 82.3 - 115.5, n = 2237, Table 28). Mean straight carapace measurements are summarised for comparison with other studies in Table 28.

There were significant differences in mean CCL among annual November-December samples (Table 24, Fig. 33). There has been a significant downward trend in mean carapace length of the nesting female *C. mydas* at Raine Island and Moulter Cay during mid summer over 26 breeding seasons, 1976-2001 ($F1,23 = 28.66$, $p<0.0005$; $r^2 = 0.555$, $df = 23$, $0.001<P<0.0025$). Within this trend, whenever there were very high density nesting seasons proximal to low density nesting seasons, there were fluctuations in mean CCL. On average smaller turtles bred in the high density nesting seasons and larger ones in the low density seasons. Parmenter (1980b) recorded significant differences in mean CCL between nesting seasons (1976-1979) for Bramble Cay *C. mydas* and attributed the differences to only the larger size turtles being able to complete physiological preparation for nesting in the low density years. We have shown the size of the annual nesting *C. mydas* population is a function of the mean May-October Southern Oscillation Index ~1.5yr before the commencement of the breeding season. Therefore we tested for a

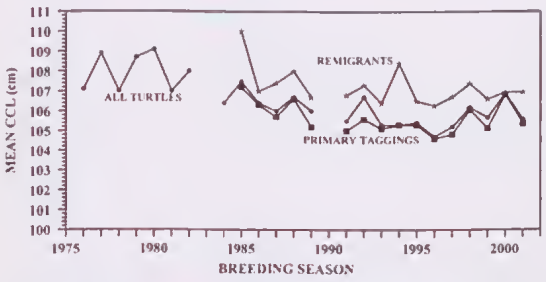

FIG. 33. Changing size (CCL) of nesting female *Chelonia mydas* recorded nesting at Raine Island and adjacent rookeries in the northern GBR during 26 years of monitoring. * = remigrants; square = primary taggings; dot = all turtles.

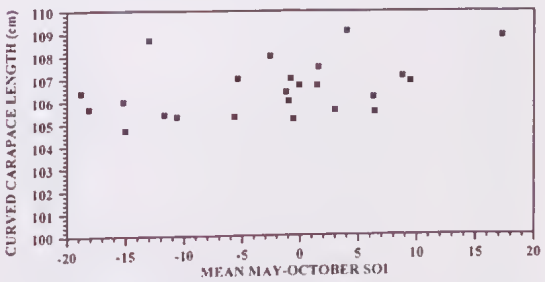

FIG. 34. Examination of a possible regional climatic regulation of the size of adult female *Chelonia mydas* nesting at Raine Island. The mean May-October SOI measured ~1.5yr before the breeding season (Table 19) was used as the measure of climate variability. Turtle size = mean carapace length measured in December (Table 24).

TABLE 24. Annual variation in curved carapace length (CCL) of nesting female *Chelonia mydas* at Raine Island and adjacent Moulter Cay ##MC) during the mid summer nesting season. Primary denotes turtles tagged for the first time in that season. Remigrant denotes turtles recorded breeding in a previous season.

Year	Rookery	All Turtles			Primary			Remigrant		
		Curved carapace length (cm)			Curved carapace length (cm)			Curved carapace length (cm)		
		Mean (Range)	SD	n	Mean (Range)	SD	n	Mean (Range)	SD	n
1976 (Dec)	RI	107.1 (93.5-124.0)	5.24	266						
1977 (Dec)	RI	108.9 (99.5-120.5)	4.39	125						
1978 (Dec)	RI	107.0 (90.5-125.0)	5.62	331						
1979 (Dec)	RI	108.7 (96.5-125.5)	4.86	390						
1980 (Dec)	RI	109.1 (96.0-124.0)	5.18	201						
1981 (Dec)	RI	107.0 (95.0-121.5)	4.96	538						
1982 (Dec)	RI	108.0 (91.0-123.0)	5.11	504						
1983-										
1984 (Dec)	RI	106.4 (93.0-119.0)	4.81	489						
1985 (Dec)	RI	107.5 (92.0-124.0)	5.41	400	107.2 (92.0-124.0)	5.47	303	110.0 (100.0-117.0)	4.07	30
1986 (Dec)	RI	106.4 (93.0-125.0)	4.82	771	106.3 (93.5-125.0)	4.83	445	107.0 (95.0-121.5)	5.17	75
1987 (Dec)	RI	106.0 (87.0-123.5)	5.34	494	105.7 (87.0-118.5)	5.36	403	107.4 (98.5-116.5)	4.43	40
1988 (Dec)	RI	106.7 (93.0-122.0)	4.85	534	106.6 (93.0-122.0)	4.73	476	108.0 (95.5-120.0)	5.09	54
1989 (Dec)	RI	106.00 (89.0-120.0)	4.92	488	105.2 (89.0-120.0)	5.30	227	106.7 (97.0-120.0)	4.48	261
1990 (Dec)	RI	106.72 (90.0-126.0)	5.23	526	106.32 (90.0-126.0)	5.37	380	107.76 (98.5-118.5)	4.72	146
1990 (Dec)	MC	107.61 (95.4-120.5)	5.49	46						
1991 (Dec)	RI	105.5 (90.9-119.4)	4.86	660	105.0 (90.9-119.4)	5.00	450	106.8 (91.2-117.3)	4.31	210
1992 (Dec)	RI	105.91 (89.5-123.0)	5.14	673	105.65 (89.5-123.0)	5.24	565	107.31 (98.5-118.0)	4.39	108
1992 (Dec)	MC	105.66 (93.0-118.5)	5.62	48						
1993 (Dec)	RI	105.31 (87.8-122.0)	5.36	1360	105.14 (87.8-122.0)	5.37	1172	106.36 (92.8-119.4)	5.13	188
1994 (Dec)	RI	105.30 (86.0-123.5)	5.49	520	105.30 (86.0-123.5)	5.56	423	108.4 (97.5-120.5)	5.48	20
1995 (Dec)	RI	105.41 (88.8-123.7)	5.28	1733	105.30 (88.8-123.7)	5.26	1468	106.49 (94.6-120.5)	5.14	141
1995 (Dec)	MC	105.40 (86.6-123.7)	5.21	109						
1996 (Dec)	RI	104.70 (86.5-127.5)	4.88	1945	104.47 (86.5-127.5)	4.90	1466	106.34 (92.5-118.4)	4.90	287
1996 (Jan)	RI	104.12 (90.2-121.0)	4.65	1180	104.15 (90.2-121.0)	4.73	822	105.61 (94.3-117.5)	4.44	88
1996 (Pooled)	RI	104.48 (86.5-127.5)	4.80	3125	104.36 (86.5-127.5)	4.84	2288	106.17 (92.5-118.4)	4.80	375
1997 (Dec)	RI	105.35 (87.2-130.1)	4.99	1861	104.82 (87.2-130.1)	4.99	1487	106.70 (90.6-121.3)	4.83	374
1997 (Dec)	MC	104.43 (92.0-119.1)	4.97	164						

TABLE 24 (*Cont.*)

Year	Rookery	All Turtles			Primary			Remigrant		
		Curved carapace length (cm)			Curved carapace length (cm)			Curved carapace length (cm)		
		Mean (Range)	SD	n	Mean (Range)	SD	n	Mean (Range)	SD	N
1998 (Dec)	RI	106.22 (91.0-126.5)	4.85	1715	106.08 (91.9-126.5)	4.80	1521	107.38 (91.0-119.7)	5.01	154
1998 (Dec)	MC	105.86 (94.2-117.4)	4.55	193	105.87 (94.2-117.4)	4.57	191			
1999 (Dec)	RI	105.59 (88.4-126.1)	5.01	2071	105.13 (88.4-126.1)	5.04	1160	106.6 (92.3-125.5)	4.87	766
1999 (Dec)	MC	105.27 (92.3-118.4)	4.79	168	105.12 (95.7-118.4)	4.84	131			
2000 (Dec)	RI	106.93 (91.5-121.3)	5.39	735	106.87 (91.5-121.3)	5.43	661	106.95 (99.0-118.8)	5.02	57
2000 (Dec)	MC	106.50 (96.6-116.1)	3.99	85	106.59 (97.3-116.1)	3.81	81			
2001 (Dec)	RI	105.58 (88.6-121.7)	4.92	1617	105.46 (91.6-120.7)	4.89	1145	106.00 (88.6-121.7)	4.98	361
2001 (Dec)	MC	105.00 (86.0-123.3)	5.04	281	105.02 (86.0-123.3)	4.97	270			

relationship between the mean May-October SOI (Table 19) measured ~1.5 yr before the *C. mydas* nesting season and mean summer CCL measured in December (Table 24). However, the mean summer CCL of the nesting females did not show a significant correlation with the mean SOI from ~1.5 yr before the breeding season ($r^2 = 0.144$, DF = 22; $F_{1,22} = 3.71$; $0.1>p>0.05$) (Fig. 34).

In contrast with the Raine Island results, Limpus et al. (1984a) found no between-season variation in the size of nesting *C. mydas* at Heron Island over eight breeding seasons, 1974-1981. Similarly there was no significant difference in CCL among annual samples from No.7 and No.8 Sandbanks (Table 26), possibly because of the small annual samples relative to the variance within the samples. No significant difference in CCL was found between the Raine Island sample and the various northern GBR island samples within any one year.

For all years except 2000 during the 17 yr period, 1985 to 2001, remigrant nesting females were significantly larger on average than females that were tagged for the first time (Table 24). The first-time-tagged group of turtles included new recruits to the nesting population as well as turtles that had nested in previous seasons but which had not been tagged. *Caretta caretta* (Limpus, 1991) and *N. depressus* (Parmenter & Limpus, 1995) nesting in the southern GBR and *E. imbricata* (Miller et al., 2000) nesting in the northern GBR display a similar characteristic of new recruits to the breeding population being smaller on average than remigrant females.

There were significant differences in mean CCL among annual November-December samples for both remigrant and primary tagged females at Raine Island across the 17 yr period, 1985-2001 (Fig. 33; Table 24) (Primary tagged turtles: $F_{16,13,735} = 15.71$, $p<0.0001$. Remigrant turtles: $F_{16,3,255} = 2.75$, $p<0.001$). There was no significant downward trend in the annual mean size of the primary tagged females across this period ($F_{1,15} = 2.36$, $0.1<p<0.25$; $r^2 = 0.136$, df = 15, $p>0.25$). Although the correlation was poor, there was a significant downward trend in the annual mean size of the remigrant turtles within the same period (Remigrant turtles: $F1,15 = 7.08$, $0.01<p<0.025$; $r2 = 0.321$ df = 15, $0.1<p<0.25$).

There was no significant log-log correlation between adult female *C. mydas* CCL and weight for the small sample weighed after completion of

TABLE 25. Annual variation in curved carapace length (CCL) of nesting female *Chelonia mydas* at Raine Island outside the mid summer nesting season.

Year, month	Curved carapace length (cm)		
	Mean (Range)	SD	n
1975 Feb	106.3 (98.0-117.0)	4.66	64
1980 Jun	110.0 (110.0)	-	1
1981 Jun	100.0 (100.0)	-	1
1982 Jul	104.3 (100.0-108.5)	-	2
1983 Apr	99.9 (94.5-104.5)	3.90	4
1984 Apr	106.1 (97.0-118.0)	4.59	77
1987 Jul	108.5 (97.5-114.5)	6.55	4
2001 Feb	104.9 (92.9-114.4)	4.09	99
combined	105.6 (92.9-118.0)	4.55	252

TABLE 26. Annual variation in curved carapace length of nesting female *Chelonia mydas* at No.7 and No.8 Sandbanks during the mid summer nesting season.

Year	Rookery	Curved carapace length (cm)		
		Mean (Range)	SD	n
1976	N8	105.6 (98.0-112.0)	4.15	14
1979	N8	107.1 (101.0-118.0)	4.69	16
1986	N7&N8	105.1 (93.0-121.0)	4.42	119
1987	N7&N8	106.3 (93.0-121.0)	5.30	169
1988	N8	107.6 (95.0-117.0)	5.07	47
1989	N8	105.9 (99.5-119.0)	5.45	10
1990	N7	106.8 (91.6-113.5)	6.14	12
1990	N8	107.5 (99.5-118.0)	4.61	25
1991	N7	104.9 (94.0-114.7)	4.63	85
1991	N8	104.6 (93.0-118.0)	6.03	56
1992	N7	106.9 (98.5-118.5)	4.16	53
1992	N8	106.6 (94.5-115.5)	4.91	63
1995	N7	106.4 (91.8-121.6)	5.32	72
1995	N8	105.6 (97.1-117.4)	4.71	80
1996	N7	105.1 (92.2-117.9)	5.75	70
1996	N8	103.8 (92.7-116.3)	4.65	54
1997	N7	105.3 (87.2-114.0)	5.29	52
1997	N8	104.7 (91.2-119.5)	5.11	185
combined	N7&N8	105.6 (87.2-121.6)	5.11	1194

laying: $\log_{10}$wt = 1.28 × $\log_{10}$CCL - 0.491 (n = 24, r = 0.606, 0.1>p>0.05. wt in kg and CCL in cm). The average female weighed 126.15kg (SD = 13.913, range = 101-154, n = 24; CCL of weighed sample ranged 95-114cm).

MALES. A series of male *C. mydas* captured while courting, or in association with courting groups on Raine Island reef (Table 28) had a pooled mean CCL = 99.4cm (SD = 4.89; range = 90.5-114.5cm; n = 37). A set of various carapace measurements using the same methodologies as used for the females is summarised in Table 28. The breeding males, on average, were very much smaller than the nesting females.

There was a significant log-log correlation between CCL and weight of breeding males at courtship: $\log_{10}$wt = 1.65 x $\log_{10}$CCL - 1.273 (n = 24, r^2 = 0.756, 0.002<p<0.005. Wt in kg and CCL in cm). The average male weighed 97.63kg (SD = 9.528, range = 83-122.5, n = 24; CCL of weighed sample ranged 90.5 - 112cm).

SIZE COMPARISONS. The size of the nesting female *C. mydas* is relatively uniform throughout the GBR rookeries with a CCL = 107cm (Heron Island: Limpus et al. 1984a; Bramble Cay: Parmenter 1979, Limpus et al., 2001). The Raine Island female *C. mydas* are of intermediate size

TABLE 27. Annual variation in curved carapace width of nesting female *Chelonia mydas* at Raine Island and Moulter Cay during the mid summer breeding season. One way ANOVA: $F_{7,2229}$ = 4.35; P<0.001, significant.

Year	Curved carapace width (cm)		
	Mean (Range)	SD	n
1974/75	98.1 (86.0-111.0)	4.92	64
1976/77	97.5 (83.0-113.0)	5.26	263
1977/78	98.9 (88.5-111.5)	4.48	125
1979/80	98.7 (86.0-115.5)	5.09	390
1980/81	98.8 (86.5-115.0)	5.37	201
1981/82	97.3 (84.0-108.5)	4.81	538
1982/83	98.2 (82.5-114.0)	5.07	504

for the species world wide, being approximately the same size as the females from the Tortuguero rookery in Caribbean Costa Rica and Aldabra Island in the Indian Ocean (Hirth, 1980). Much smaller sized females nest in Hawaii, the Arabian Peninsula and the eastern Pacific Ocean while considerably larger sized nesting females occur at Europa Island, Surinam and Ascension Island (Hirth, 1980; Miller, 1989).

The mean CCL of the dead females recorded on Raine Island over 18 breeding seasons (Table 16) was smaller than the mean CCL of the nesting female sample recorded in the respective breeding seasons (Table 24). Why the death of the nesting female should be size related is not clear. To address this question, detailed autopsies of turtles dying from a variety of causes are needed to identify the extent to which the mortality is related to the turtle being small, irrespective of its past breeding history, or to newly recruited turtles to the breeding population. This bias in the death of smaller turtles is contrary to the bias that would be needed for the death of nesting turtles on these islands to be the primary cause of the long term reduction in CCL of turtles breeding at Raine Island and Moulter Cay.

Size is not a reliable measure of maturity or age in adult marine turtles (Limpus & Reed, 1985a,b; Limpus et al., 1994e; Limpus & Chaloupka, 1997) and not all turtles reach sexual maturity at the same size (Limpus, 1991). Therefore the question of why there are inter-rookery and inter-seasonal differences in CCL of nesting females probably cannot be resolved by studies at the rookeries. The size of the breeding female should be a function of a number of factors, including its genetic stock, the climate of its particular feeding area, its diet and its breeding age. Potentially all these factors can now be

TABLE 28. Carapace measurements of adult male and female *Chelonia mydas* breeding at Raine Island and adjacent islands.

	Measurement (cm)		
	Mean (Range)	SD	n
Female			
Straight carapace length: 1978/79	100.3 (89.0-107.6)	4.37	54
Straight carapace width: 1978/79	76.3 (68.6-90.0)	3.76	54
Carr's straight carapace length: 1978/79	99.7 (93.0-109.3)	3.69	29
Male			
CCL: 1978/79	98.5 (90.5-112.0)	4.36	28
CCL: 1979/80	103.7 (103.0-104.5)	0.76	3
CCL: 1982/83	96.0 (-)	-	1
CCL: 1987/88	102.4 (90.5-114.5)	6.51	5
Curved carapace width: 1978/79	88.8 (82.5-97.0)	4.50	28
Straight carapace length: 1978/79	93.1 (86.9-102.5)	3.37	25
Straight carapace width: 1978/79	71.0 (66.1-78.2)	3.34	24
Carr's straight carapace length: 1978/79	93.0 (88.4-98.4)	2.74	14

addressed in studies of *C. mydas* in its feeding areas. The north-south distribution of the eastern Australian feeding areas and the capacity to identify the genetic stock of individual turtles make the eastern Australian turtles ideally located for further studies on what determines the size composition of the nesting population.

EGG PRODUCTION

NESTING SUCCESS. Observations of individual turtles ashore through the night have shown that a female does not always successfully lay her eggs on each nesting crawl. During 22 November - 16 December 1986, 26 nesting females were followed for their entire time ashore. Of these, only four were observed to lay eggs (nesting success = 0.15).

It was concluded from the results of autopsies of turtles dying while ashore at Raine Island that only females attempting to nest come ashore. When a turtle comes ashore and fails to lay her eggs it should result primarily from negative impacts on the turtle while it is ashore. Two principal sets of factors that contribute to whether or not a turtle will successfully lay during a nesting crawl on these remote northern GBR beaches are identified.

FIG. 35. Adult female *Chelonia mydas* wandering into each other as they searched for nesting sites at Raine Island, 19 December 1984. The nett result of these interactions is that turtles spread more widely across the beach and spend more time ashore for nesting than would occur in a low density nesting situation.

1) Environmental disturbance. The sand of Raine Island beach was very dry, and without grass/tree roots to bind it together. The coralline sand particles did not adhere readily. The dryness and looseness of the sand generally resulted in the digging of very deep body pits with the associated likelihood of collapse of the body pit wall into the egg chamber. Egg chambers were repeatedly collapsing as the females attempted to dig their nests. Turtles with damaged hind flippers had even more problems in digging if this hampered their ability to lift sand from the egg chamber. Bustard & Greenham (1968) discussed this problem for the Heron Island *C. mydas* nesting population. Another potential cause of disturbance to the nesting turtle on these islands was buried rocks, timber and turtle bone. Large obstructions could prevent the turtle digging an egg chamber, but this type of problem occurred less frequently. It mostly confronted those turtles that attempted to nest on top of the phosphatic limestone platform.

2) Turtle interactions. Most turtles, when undisturbed, made their first nesting attempt for the night near the crest of the outer beach rim. When turtles were beaching at a density that resulted in approximately overlapping turtles around the perimeter of the beach in the early part of the night, i.e. 1 turtle per 2m of beach line, there was a high probability of a turtle encountering another turtle already ashore (Fig. 34). Therefore, with higher density nesting (mean nightly tally count exceeding ~900), turtles that beached early in the night and become established in nest digging were often disturbed

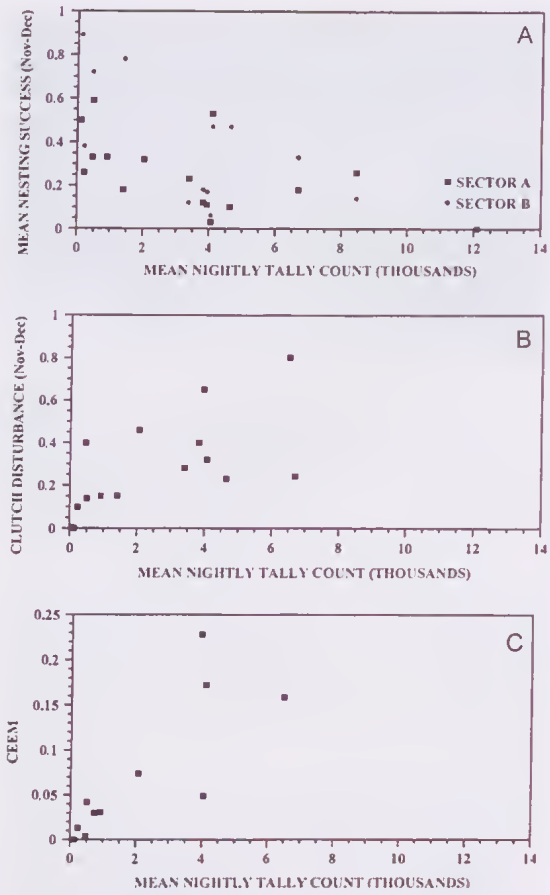

FIG. 36. Variation in annual nesting success (A), rate of clutch disturbance by nesting turtles (B) and clutch equivalent egg mortality (CEEM) (C) for *Chelonia mydas* breeding at Raine Island with respect to nesting density. See Table 29 for seasonal data.

by later arrivals. This usually resulted in the one or both turtles moving on to seek an alternative nest site further in from the water line. Disturbance that caused a turtle to abandon a site ranged from one turtle bumping another to a turtle that was digging a nest throwing sand into the face of another. A person walking near or gently touching a turtle wandering on the beach platform on a high density turtle night appeared to make no additional impact on the nesting success of the turtle which was already reacting to regular 'disturbance'.

It was not uncommon for turtles to be ashore for over 6hr, alternately wandering and digging without successfully constructing a nest before returning to the sea. Without a completed nest, the turtle would not lay. Difficulties in preparing a nest and completing a laying will increase the time a turtle spends on the beach and hence increase the probability of still being ashore after daylight. This in turn increases the probability of heat induced mortality. Hence at Raine Island, death on the nesting beach is density dependent on the size of the nightly nesting numbers.

The nesting success recorded in 1986 above contrasted with the nesting success recorded for individual turtles during low density nesting in April 1984 at Raine Island. Of 165 recorded beachings, 109 (66%) resulted in laying, 41 (25%) resulted in the turtle leaving the beach without laying and 15 (14%) were not assessed for nesting success. During this visit, it rained on 7 of the 23 days/nights and the sand was noticeably moist and egg chambers appeared to be dug easily without the walls collapsing. The combination of low nesting density (daily number of beachings = 3 - 17) (Table 3) and moist sand appears to have contributed to the high nesting success (= 0.73 for the 150 beachings assessed for nesting success) at this time. These data illustrate the variability that can occur in nesting success for turtles attempting to nest in coralline sand. Similar intra-seasonal variability in nightly nesting success has been described *C. mydas* attempting to nest in similar coralline sand at from Bramble Cay (Limpus et al., 2001).

For a more rapid assessment of nesting success, sampling sites A to E (Fig. 2) were selected and where possible, nesting success was quantified on opposite sides of Raine Island on the same night. Nightly nesting success recorded in these sectors for the November-December sampling periods is summarised in Table 29. The mean nightly nesting success data showed a significant correlation with the mean tally count (MTC) for the respective sampling period (Fig. 35A): nesting success = $-0.000042 \times MTC + 0.4411$ ($F_{1,15} = 19.69$; $p<0.001$; significant. $r^2 = 0.565$, DF = 15.). Nesting success, measured at a standard sampling period across several breeding seasons, is therefore negatively correlated with the density of the nesting turtles on the island. However, factors such as how recently it rained and the amount of rainfall can vary on a daily basis within and between seasons and will influence nesting success by changing the adhesion of the sand particles.

When a turtle does not lay her eggs on one night she attempts to nest again on the same or on one of the following nights (Miller, 1985). This can be repeated a number of times until the turtle

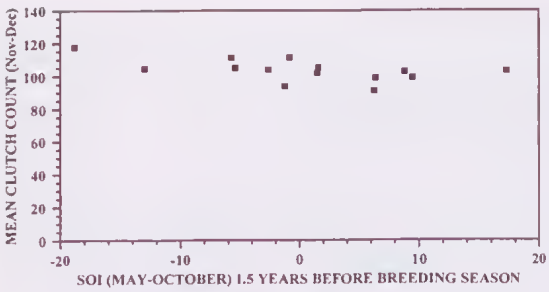

FIG. 37. Comparison of the mean November-December clutch count for adult female *Chelonia mydas* nesting at Raine Island (Table 29) with the mean May-October Southern Oscillation Index (SOI) approximately 1.5 yr before the breeding season (Table 19).

eventually lays her clutch. When a factor such as nesting density contributes to lowered nesting success, it results in the female having to make more nesting crawls per clutch.

Within the one nesting season, because nesting density will be low at the beginning and end of the season and maximal in December and January, nesting success must vary throughout the season. In the absence of rain, the trend should be for nesting success to be minimal in December and January.

RENESTING INTERVAL. Renesting interval is measured as the time from successfully laying a clutch to the return of the turtle to the beach to attempt to lay her next clutch. During most visits to Raine Island, the high density nesting precluded spending the time with each turtle to establish its nesting success for the night. High nesting density also made it difficult to examine every turtle ashore for the night to check it for tags and hence establish its identity. Therefore, on most visits it was not possible to reliably measure renesting interval at Raine Island and Moulter Cay.

During the April 1984 visit to Raine Island, nesting density was low enough for the nesting success of almost every turtle for the night to be assessed. Because of this, it was possible to record the timing of subsequent returns of females following a successful nesting. The mean renesting interval was 12.4 d (SD = 1.02, range = 10-14, n = 16). This is very similar to the mean renesting interval of 12.0 d (SE = 0.04, range = 9 - 21, n = 979) and 12.4 d (SD = 1.67, range = 9-19 d, n = 2781) measured over an entire nesting season at Bramble Cay during the 1978/79 and 1979/80 breeding seasons, respectively (Parmenter, 1979; Limpus et al., 2001). These values recorded within the nGBR *C. mydas* stock are considerably shorter than the renesting interval for the species at Heron Island in the southern GBR (renesting interval: 13.52 d in 1974/75; 14.08 d in 1980/81. Limpus, 1980b; Limpus et al., 1984a). These differences are more likely to be the result of different water temperatures in the interesting habitat during the oviducal phase of embryogenesis and egg shell formation (Miller, 1985) rather than a genetic difference between the stocks.

NESTING BEACH FIDELITY. Once nightly tagging of nesting turtles at Raine Island commenced on each sampling trip there were numerous recaptures of these tagged turtles on subsequent nights at Raine Island. For example in November 1984, 77 recaptures of recently tagged turtles were made over the 2nd to 10th night of tagging on the island. These were of turtles that had not completed a successful nesting on the previous beaching. When Moulter Cay was visited after a period of intense tagging at Raine Island there were small numbers of recaptures of nesting females that had been tagged while attempting to nest at Raine Island within the previous few nights (50 recaptures) (Table 8). Two similar recaptures of turtles changing islands have been made on Raine Island when intense tagging on Moulter Cay was followed by work on Raine Island (Table 7). There have been no within season changes of rookery recorded from the studies at MacLennan Cay, No.7 and No.8 Sandbanks. There has been no record of intra-seasonal *C. mydas* interchange between the northern and southern GBR rookery areas.

These observations are consistent with those from more detailed long term recapture studies of *C. mydas* at other rookeries (Heron Island: Bustard, 1972, Limpus et al., 1984a; Sarawak Turtle Islands: Hendrickson, 1958; Hawaii: Balazs, 1980; Tortuguero: Carr et al., 1978). *C. mydas* displays a high level of fidelity to the individual nesting beach with only a small percentage of the females interchanging between nearby rookeries within the same nesting season.

EGGS. *C. mydas* of the nGBR stock lay the typical white, approximately spherical, soft shelled eggs for the species. The mean clutch counts recorded across the breeding seasons at Raine Island and No. 7 and No. 8 Sandbanks are summarised in Table 30. There was a significant difference among the annual samples of clutch counts. The combined seasons mean clutch count

TABLE 29. Nesting success and clutch disturbance measurements for *Chelonia mydas* at Raine Island. Measurements made in sampling sites A and B (Fig. 2).

Date	Sector	Turtles entering sector		Number of clutches laid	Number of existing clutches disturbed	Nesting success	Clutch disturbance rate
		From beach	From sides				
		X	Y	Z	C	Z/X	C/Z
12/12/81	A	222	-	75	25	0.34	0.33
13/12/81	A	170-200	-	57	35	~0.31	0.61
1981					Combined values	~0.32	0.46
29/12/82	A	52	-	20	2	0.38	0.10
3/12/82	A	93	-	34	5	0.37	0.15
6/12/82	A	93	-	25	5	0.27	0.20
1982					Combined values	~0.33	0.15
28/11/85	A	20	0	3	0	0.15	0
1/12/85	A	16	1	2	0	0.13	0
9/12/85	A	27	4	8	1	0.30	0.13
16/12/85							
1985	A				Combined values	0.26	0.12
28/11/85	B	9	4	4	0	0.44	0
3/12/85	B	20	2	7	1	0.35	0.14
13/12/85	B	13	3	2	1	0.15	0.50
16/12/85	B	22	3	11	0	0.50	0
1985	B	Combined values			Combined values	0.38	0.08
28/12/86	A	313	-	37	20	0.12	0.54
4/12/86	A	449	-	50	17	0.11	0.34
8/12/86	A	520	-	47	28	0.11	0.60
12/12/86	A	369	-	47	21	0.13	0.45
1986	A	Combined values			Combined values	0.11	0.48
26/11/86	B	216	-	24	23	0.11	0.11
2/12/86	B	275	-	35	37	0.13	1.06
6/12/86	B	334	-	58	44	0.17	0.80
10/12/86	B	241	-	34	20	0.14	0.59
1986	B	Combined values			Combined values	0.17	0.82
3/12/87	A	330	-	35	30	0.11	0.86
1/12/87	B	73	-	24	7	0.33	0.29
6/12/88	A	78	10	39	5	0.50	0.13
7/12/88	A	74	17	31	0	0.42	0
8/12/88	A	76	21	50	9	0.66	0.18
1988	A	Combined values			Combined values	0.53	0.12
6/12/88	B	33	8	24	5	0.73	0.21
7/12/88	B	33	10	15	6	0.46	0.40
8/12/88	B	80	10	29	5	0.36	0.17
1988	B	Combined values				0.47	0.24
6/12/91	A	157	65	11	9	0.07	0.82
8/12/91	A	117	63	22	10	0.19	0.45
1991	A	Combined values				0.12	0.58
6/12/91	B	125	74	23	2	0.18	0.09
8/12/91	B	77	65	14	6	0.18	0.43
1991	B	Combined values				0.18	0.22
6/12/92	A	122	12	24	3	0.20	0.13
8/12/92	A	134	38	21	5	0.16	0.24
1992	A	Combined values				0.18	0.18
6/12/92	B	35	27	20	5	0.57	0.19
8/12/92	B	44	32	42		0.95	0.06

TABLE 29 (*Cont.*)

Date	Sector	Turtles entering sector		Number of clutches laid	Number of existing clutches disturbed	Nesting success	Clutch disturbance rate
		From beach	From sides				
		X	Y	Z	C	Z/X	C/Z
1992	B	Combined values				0.78	0.11
4/12/93	A	131	43	25	9	0.19	0.36
6/12/93	A	87	124	31	10	0.36	0.32
1993	A	Combined values				0.26	0.34
4/12/93	B	77	30	14	2	0.18	0.1
6/12/93	B	119	37	14	11	0.12	0.79
1993	B	Combined values				0.14	0.46
6/12/94	A	13	3	9	0	0.69	0
8/12/94	A	36	3	20	1	0.56	0.05
1994	A	Combined values				0.59	0.03
6/12/94	B	86	16	32	8	0.37	0.25
8/12/94	B	27	14	5	1	0.19	0.2
1994	B	Combined values				0.33	0.24
6/12/95	A	413	100	57	12	0.13	0.21
12/12/95	A	323	126	18	5	0.06	0.29
1995	A	Combined values				0.10	0.23
6/12/95	B	99	113	52	12	0.53	0.23
12/12/95	B	88	64	35	8	0.40	0.13
1995	B	Combined values				0.47	0.23
2/12/96	A	259	146	1	11	0.004	11.0
4/12/97	A	495	86	20	7	0.03	0.35
4/12/97	B	465	34	28	8	0.06	0.29
30/11/98	A	29	7	11	0	0.38	0
6/12/98	A	26	4	8	0	0.31	0
1998	A	Combined values				0.33	0
6/12/98	B	60	5	47	5	0.72	0.11
30/11/98	C	29	7	11	0	0.31	0
7/12/98	D	30	5	11	1	0.31	0.09
7/12/98	E	47	2	28	0	0.57	0
1/12/99	B	212	59	53	17	0.22	0.32
8/12/99	B	272	117	90	10	0.34	0.11
1999	B	Combined values				0.30	0.19
1/12/99	D	589	34	93	6	Incomplete sampling	0.06
8/12/99	D	328	183	59	7	0.18	0.12
1999	D	Combined values				0.18	0.09
1/12/00	A	11	0	6	0	0.55	0
4/12/00	A	5	1	2	0	0.40	0
2000	A	Combined values				0.50	0
1/12/00	B	12	1	10	0	0.83	0
4/12/00	B	6	1	6	0	1.00	0
2000	B	Combined values				0.89	0
4/12/01	A	115	34	34	6	0.23	0.18
4/12/01	C	199	49	29	11	0.12	0.38

of 104.3 for the November- Deeember nesting period at Raine Island was very similar to the mean eluteh eount of 103.8 measured for the two samples from No. 7 and No. 8 Sandbanks. There was no signifieant eorrelation between annual November-Deeember eluteh eount and the southern oseillation index measured approximately 1.5 yr before the nesting season

TABLE 30. Comparison of annual clutch counts of *Chelonia mydas* from Raine Island and No. 7 and No. 8 Sandbanks.

Year	Clutch count			
	Mean	SD	Range	N
Raine Island: November-December				
1976/77	102.7	19.02	63-147	48
1977/78	103.1	21.34	65-166	38
1978/79	105.1	19.31	69-143	59
1979/80	104.3	24.85	59-158	24
1981/82	111.3	17.25	79-152	20
1982/83	103.9	12.32	79-123	22
1984/85	117.8	22.13	62-175	36
1985/86	106.2	19.51	76-163	38
1986/87	93.9	14.50	66-130	39
1991/92	99.1	21.37	62-142	45
1992/93	101.8	14.0	73-130	54
1994/95	111.2	19.65	75-139	40
1995/96	100.7	23.6	47-124	9
1997/98	118	-	118	1
1998/99	91.1	18.92	65-142	20
2000/01	99.0	18	72-126	8
Combined	103.88	19.83	47-175	501
One way ANOVA: $F_{15,485} = 3.60$; $p<0.001$; significant				
Raine Island: April				
1983/84 (Apr)	83.3	17.82	62-111	7
No.7 and No. 8 Sandbanks: December				
1988/89	116.0	26.55	88-147	4
1991/92	97.4	19.19	68-118	6
Combined	104.84	25.52	68-147	10

($F_{1,14} = 3.43$; $0.2>p>0.1$. $r^2 = 0.196$, DF = 14) (Fig. 36). However, the clutch count from the extreme El Nino and La Nina years are very poorly represented in the samples (Fig. 36). This relationship warrants further investigation.

No attempt has been made to record successive clutches from the same turtle within a breeding season at Raine Island. The smaller clutches laid in April (Table 30) are consistent with the decline in clutch count that Parmenter (1979) recorded with the last clutch for the season with each turtle at Bramble Cay. The mid season clutch count (Table 30) and egg diameters from Raine Island (Table 32) is very similar to the December clutch counts and egg diameters from Bramble Cay (Parmenter, 1979) and the mean clutch count of 102.2 measured across the entire breeding season at Bramble Cay in 1979/80 (Limpus et al., 2001). Clutch counts from Heron Island (Bustard, 1972; Limpus, 1980b; Limpus et al., 1984a) are higher than the clutch counts recorded in most years at Bramble Cay and Raine Island. When compared

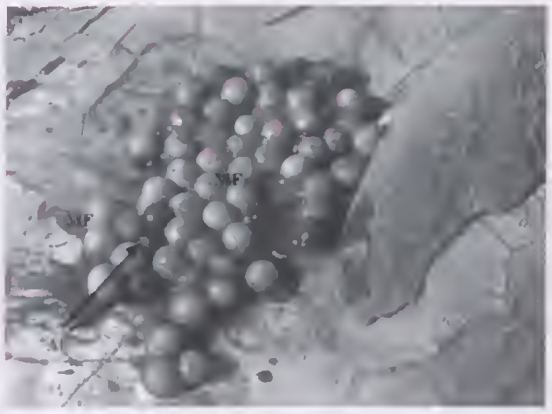

FIG. 38. Portion of an ovary from an breeding female *Chelonia mydas* that died while ashore for nesting on Raine Island, 9 December 2002. In addition to the normal 25-32mm diameter mature follicles (MF), this turtle had many large 25-32mm diameter atretic follicles (AF).

worldwide, *C. mydas* clutch counts and egg diameters from the various rookeries scattered within the GBR are relatively uniform and occur close to the middle of the range for the species (Hirth, 1980; Miller, 1989).

Counting the number of eggs in a clutch at Raine Island is complicated by the disturbance of nesting turtles by other turtles. A turtle that has been disturbed before she has laid any eggs from the current clutch can be expected to return to lay those eggs later on the same night or on a subsequent night without reducing the number of eggs in her clutch (Miller, 1985; Limpus, 1985). However, if a turtle has laid part of her clutch and is disturbed while laying, she can be expected to cease laying the remainder of the clutch and move off the nest with the following consequences (Miller, 1985; Limpus, 1985). If she has laid less than approximately half a clutch, she can be expected to return to lay the remainder of the clutch either on the same night or within the next few nights. In this case she will have deposited two 'clutches', each with less than less than the actual clutch count. Should she have laid more than half a clutch before she was disturbed, she is unlikely to return to lay the remainder of that clutch on the beach. She will normally return in about two weeks to lay a complete clutch. Some turtles can be seen laying small numbers eggs as they return across the beach to the sea at Raine Island. On occasions, turtles can be seen underwater and resting under ledges along the edge of Raine Island Reef with small clusters of

TABLE 31. Frequency of occurrence of yolkless and multiyolked eggs in *Chelonia mydas* clutches at Raine Island. Unless otherwise stated, measurements were recorded in November - December.

Year	Yolkless eggs per clutch				Multiyolked eggs per clutch			
	Mean	SD	Range	n	Mean	SD	Range	n
1976/77	0.05	0.224	0-1	20	0		0	20
1977/78	0.13	0.404	0-2	40	-			
1978/79	0.10	0.399	0-2	60	0		0	60
1979/80	0.04	0.204	0-1	24	0		0	24
1981/82	0.18	0.529	0-2	62	-			
1982/83	0.09	0.288	0-1	23	-			
1983/84 Apr	0.14	0.350	0-1	7	0		0	7
1984/85	0.11	0.393	0-2	36	0.17	0.697	0-4	36
1985/86	0.11	0.383	0-2	39	0.03	0.160	0-1	39
Combined	0.12	0.399	0-2	349	0.03	0.290	0-4	224
One way ANOVA	$F_{9,339} = 0.37$; $p>0.25$; not significant				$F_{6,217} = 1.69$; $0.1>p>0.25$; not significant			

eggs under the tail. In both these cases, it is presumed that these are females that have been disturbed after they have laid more than half a clutch and were voiding the remainder of that clutch. For these turtles, the 'clutch' laid on the beach is less than a complete clutch and the voided eggs represent a loss of eggs to the rookery. Thus in high density nesting seasons, there will be a number of apparent clutches counted that will be less than a complete clutch. The impact of this turtle-turtle disturbance in altering the average number of eggs in a clutch remains unquantified. Of greater consequence in high density nesting seasons should be the depletion of the stored fat reserves if the turtle makes numerous unsuccessful nesting crawls over an extended series of nights. The turtles seen at necropsy that have large numbers of mature sized, atretic follicles are believed to be turtles from this latter category that have commenced mobilisation of the nutrient and energy reserves of some mature follicles to maintain their nesting activity and possibly support their homeward migration. For these turtles, the consequence of repetitive disturbance would include a reduction in the number of clutches she can lay for the season. While the impact also remains unquantified, there is a density dependent effect in high density nesting seasons that should result in a reduction in clutch count and a reduction in the number of clutches laid for the season.

TABLE 32. Seasonal variation in *Chelonia mydas* egg diameters at Raine Island and No.8 Sandbank. 10 eggs measured per clutch during November - December.

Year	Egg diameter			
	Mean	SD	Range	N
Raine Island				
1976/77	4.38	0.081	4.15-4.56	160
1977/78	4.44	0.163	4.10-5.38	400
1978/79	4.39	0.138	4.01-4.70	460
1981/82	4.37	0.129	3.93-4.67	200
1982/83	4.42	0.114	4.18-4.60	200
1983/84 (Apr)	4.33	0.179	3.86-4.61	70
1984/85	4.40	0.132	3.93-4.85	390
1985/86	4.36	0.119	4.03-4.58	240
1986/87	4.34	0.127	3.86-4.78	390
1988/89	4.33	0.126	4.11-4.58	540
1991/92	4.34	0.117	4.02-4.59	450
1993/94	4.25	1.87	3.66-5.09	950
1994/95	4.30	0.131	3.84-4.67	44
No. 7 and No. 8 Sandbanks				
1988/89	4.31	0.161	4.11-4.50	40
1991/92	4.31	0.105	4.19-4.42	60
All combined	4.34	0.860	3.66-5.38	4594
One way ANOVA: $F_{14,4579} = 1.56$; $0.1>p>0.05$; not significant				

Yolkless eggs and multiyolked eggs were uncommon and there was no significant difference in the occurrence of yolkless eggs or multiyolked eggs per clutch among the seasons (Table 31). The low frequency of yolkless eggs per clutch is typical of the species from the non Arabian Peninsula rookeries (Miller, 1989).

There were significant differences in the mean egg diameter between clutches laid by different females within the one breeding season (one way ANOVA, $p<0.001$ in each season). The seasonal samples of clutch counts are summarised in Table 32. There were no significant differences in egg diameters among nesting seasons or between

TABLE 33. Depth from beach surface to top and bottom of *Chelonia mydas* clutches at Raine Island, measured from the beach surface at the completion of laying.

Year	Nest depth to top of eggs (cm)				Nest depth to bottom of eggs (cm)			
	Mean	SD	Range	N	Mean	SD	Range	N
1977/78	70.0	-	70	1	85.7	9.81	74-98	3
1978/79	52.0	11.40	36-77	20	75.7	12.36	60-100	17
1979/80	51.8	13.53	33-88	24	91.1	19.73	64-152	16
1981/82	-				82.5	15.73	55-96	60
1982/83	-				78.2	7.78	60-95	26
1992/93	-				79.5	9.64	66-90	11
1994/95	-				81.0	18.12	65-109	5
Combined	52.3	12.61	33-88	45	81.63	14.73	55-152	138
One way ANOVA	$F_{2,42} = 1.01; p>0.25$; not significant				$F_{6,131} = 1.99; 0.1>p>0.05$; not significant			

Raine Island and No. 8 Sandbank. The mean size of the eggs laid by nGBR stock *C. mydas* (Table 32) are very similar is size to those laid by sGBR stock females (Limpus et al., 1984a). However, in the extremes, the smallest nGBR *C. mydas* eggs were smaller than eastern Australian *Caretta caretta* eggs (Limpus et al., 1984a) and the largest eggs were comparable in size to eastern Australian *N. depressus* eggs (Limpus, 1971).

Given the similarity of the recorded data from Raine Island with that from Bramble Cay and the difficulty of repetitively sampling the same female at Raine Island to determine valid whole season values for most clutch related parameters and for renesting interval, it is proposed that the Bramble Cay clutch data and renesting interval should be used to describe these parameters for Raine Island turtles.

NEST DEPTH. Depths of eggs within the sand at the completion of laying are summarised in Table 33. No significant inter-seasonal difference in nest depth was detected (Table 33). The mean depth to the top of a clutch was 52.3cm and the mean depth to the bottom of a clutch was 81.6cm. These nest depths are considerably deeper than nests constructed by sGBR stock females (Limpus et al., 1984a).

EGG MORTALITY CAUSED BY NESTING TURTLES. Some nesting turtles dig into existing clutches (Fig. 37) as they prepare their own nests. It is unusual for the entire existing clutch to be disturbed, either by being dug out or rolling down into the new egg chamber. When incubating turtle eggs are moved there is a high probability of mortality unless care is taken in their handling (Limpus et al., 1979; Parmenter, 1980b). Eggs dug up by nesting turtles are jarred violently and even if they are not broken in the process, they are most likely killed as they are thrown out. In addition, eggs thrown to the surface and surviving the jarring are most likely to desiccate in the hot dry sand by day and die. Thus the eggs thrown out of existing clutches by nesting turtles are regarded as totally killed. When these eggs are eaten by birds it will be treated as scavenging rather than predation, since birds are not the primary cause of the mortality. At Raine Island and Moulter Cay, buff-breasted landrails, rufous night herons, silver gulls and all the species of terrestrial crabs regularly scavenged on turtle eggs brought to the surface by nesting turtles. Egg mortality caused by nesting turtles was measured in a two step process that quantified the rate of disturbance of clutches by nesting turtles and quantified egg mortality per disturbed clutch.

Clutch Disturbance by Nesting Turtles. Two counts of clutch disturbance by nesting turtles have been measured over the entire beach at Raine Island during periods of low density nesting. 1980/81, 8-12 December: In this very low density nesting season only 1 clutch was

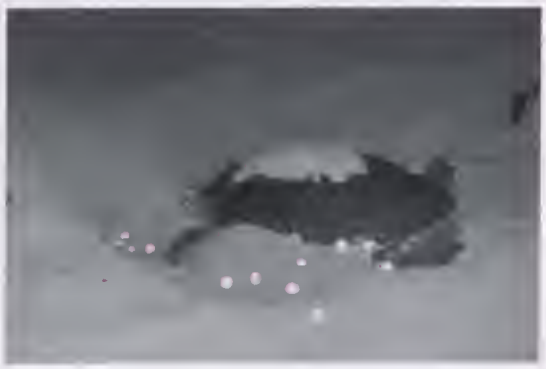

FIG. 39. Loss of eggs as a nesting turtle digs into an existing clutch at Raine Island, 19 December 1984.

TABLE 34. Number of eggs destroyed per clutch when nesting *Chelonia mydas* dug into existing clutches at Raine Island. Samples were taken from throughout the nesting habitat of the island.

Sampling period	Egg mortality per disturbed clutch			
	Mean	SD	Range	N
Raine Island				
1981: 12 Nov-15 Dec	18.0	13.69	2-54	33
1982: 11 Nov-10 Dec	21.6	15.53	6-62	21
1984: 21 Nov-23 Dec	23.3	13.15	5-61	49
1985: 29 Nov-19 Dec	14.0	13.24	1-71	44
1986: 22 Nov-16 Dec	32.9	26.62	4-125	70
1987: 29 Nov-5 Dec	28.0	12.78	12-59	11
1988: 29 Nov-8 Dec	16.9	5.65	2-59	48
1994: 30 Nov-10 Dec	33.5	18.2	1-82	4
1996: 1-12 Dec	10.8	8.8	2-40	80
1997: 29 Nov-19 Dec	18.2	12.95	1-62	74
1998: 30 Nov-7 Dec	8.18	7.15	1-25	11
1999: 28 Nov-11 Dec	15.3	11.11	1-50	241
2001: 1-10 Dec	19.77	13.81	2-77	128
Combined	18.28	14.881	1-125	814
One way ANOVA: $F_{12,801} = 11.94$; $p<0.001$; significant				

disturbed by nesting turtles in 5 successive nights of observation. With approximately 81 nesting females ashore per night on the whole island, if nesting success is assumed to be at least 50% then this would give an estimated nightly clutch disturbance by nesting turtles for the entire island = 0.005 (Table 35). 1982/83, April: In five nights, a total of 16 beachings occurred (Table 3) but no incubating clutches were disturbed by the nesting turtles. This is the only measure of clutch disturbance from late in a nesting season.

For a more rapid assessment during higher density nesting seasons, clutch disturbance was quantified in the same sampling sites, A to E (Fig. 2), on Raine Island as were used for measuring nesting success. Nightly clutch disturbance by the nesting turtles during November-December within these sites is summarised in Table 29. These clutch disturbance data, combined with those from following individual females, showed a significant correlation with the mean tally count (MTC) for the respective sampling period (Fig. 35B): clutch disturbance = 0.000548 × MTC + 0.9118 ($F_{1,16} = 15.90$; $p<0.001$; significant. $r^2 = 0.4984$, DF = 16.). Clutch disturbance by nesting turtles, measured in a standard sampling period across several breeding seasons, is therefore positively correlated with the density of the nesting turtles on the island. Since the density of clutches in the beach will increase through the nesting season until substantial numbers begin

TABLE 35. Turtle induced egg mortality - a summary of the annual egg mortality per disturbed clutch (EMpDC), rate of clutch disturbance (CD) and clutch count recorded for *Chelonia mydas* at Raine Island (From Tables 34, 29, 30 respectively.). The clutch equivalent egg mortality per clutch laid (CEEM) was calculated as: CEEM = (EmpDC × CD)/clutch. * denotes an estimated value.

Sampling period	EMpDC	CD	Clutch count	Clutch equivalent of eggs killed per clutch laid
November-December				
1980	-	0.005	-	0.001*
1981	18.0	0.46	111.3	0.074
1982	21.6	0.15	103.9	0.031
1984	23.3	0.80*	117.8	0.158*
1985	14.0	0.10	106.2	0.013
1986	32.9	0.65	93.9	0.228
1987	28.0	0.58	94.6	0.172
1988	16.9	0.18	102.2	0.030
1991	-	0.40	99.1	-
1992	-	0.15	101.8	-
1993	-	0.40	-	-
1994	33.5	0.14	111.2	0.042
1995	-	0.23	100.7	-
1996	10.80	11.0	-	-
1997	18.2	0.32	118.0	0.049
1998	8.18	0.04	91.1	0.040
1999	15.30	0.14	-	-
2000	-	0	99.0	0
2001	19.77	0.28	-	-
April				
1983	-	0	-	0

hatching, clutch disturbance should also be a function of when in the nesting season it is measured. Thus the above mid season measurements cannot provide a total seasonal summary of clutch disturbance by nesting turtles.

Egg Mortality Per Disturbed Clutch. The number of eggs dug from existing clutches when a nesting turtle disturbed them was counted for a series of clutches in most breeding seasons (Table 34). There were significant inter-seasonal differences in egg mortality per disturbed clutch (one way ANOVA: $F_{12,801} = 11.94$; $p<0.001$; significant) but there was no significant correlation detected between egg mortality per disturbed clutch and the mean tally count of the sampling period ($F_{1,11} = 0.305$; $p>0.25$. $r^2 = 0.027$, DF = 11). The mean egg mortality per disturbed clutch, pooled across the nesting seasons was = 18.3 (Table 34).

The rate of egg loss per clutch laid during each sampling period is expressed as a clutch

TABLE 36. Straight carapace length and weight of hatchling *Chelonia mydas* from Raine Island. h denotes hatchlings, c denotes clutches.

Breeding Season	Straight carapace length (cm)			Weight (g)			Sample
	Mean	SD	range	Mean	SD	range	
1974/75: Feb	4.91	0.191	4.17-5.22	23.9	1.92	17.5-27.5	69 h, 7 c
1978/79: Dec	4.80	0.099	4.70-5.00	22.9	0.88	21.5-24.5	8 h, 1 cl
1979/80: Jun	4.83	1.978	3.84-5.17	22.6	1.6	18.0-25.0	57 h, 6 c
1982/83: Apr	4.83	0.160	4.31-5.14	24.5	1.95	20.0-28.5	100 h, 10 c
1983/84: Apr	4.87	0.183	4.25-5.43	23.8	1.91	18.5-29.5	460 h, 46 c
Combined	4.86	0.588	3.84-5.43	23.8	1.92	17.5-29.5	694 h, 70 c

equivalent egg mortality (CEEM) and is tabulated in Table 35. When the annual CEEM values for the December sampling period are correlated against the respective mean tally counts (MTC. Table 35), there was a very obvious positive correlation of egg mortality with nesting density (Fig. 35A): CEEM = 0.000036MTC × 0.002125 ($F_{1,8}$ = 14.88; 0.0025>p>0.001. r^2 =0.6504; DF = 8). The clutch equivalent egg mortality varied from a low value of approximately zero in December 2000 and 0.005 in December 1980 to 0.23 during dense nesting in December 1986. There is also the potential for substantial intra-seasonal variability, particularly in the early and late breeding seasons relative to mid season. For example, CEEM was approached towards the end of the 1982/83 nesting season. The data (Fig. 32) suggest that there will be a definable mathematical relationship between CEEM and the mean tally count that should have potential in modelling the seasonal egg mortality caused by nesting turtles. However, to achieve this it will be necessary to systematically sample from additional medium to very high density nesting seasons to establish the relationship with any precision. Additionally it will be necessary to determine the variability of CEEM throughout several breeding seasons with differing nesting densities and relate the within season model to the standard sampling period data that can be gathered over a larger series on breeding seasons.

Bustard & Tognetti (1969) proposed that *C. mydas* clutch destruction at Heron Island was density dependent on the size of the nesting population. However, they did not precisely define their methodology. Bustard & Mathers (1975, unpubl., reported in Bustard, 1976) indicated that there was substantial destruction of *Caretta caretta* clutches by nesting *C. mydas* at Heron Island. Studies at Heron Island (Limpus unpubl. data) have been unable to reproduce comparable data sets to those in the above studies. The data as presented by Bustard & Tognetti (1969) suggests that nesting densities such as those at Raine Island and Moulter Cay are unsustainable. It would be appropriate at this time to investigate new models to describe the possible role density dependent egg destruction by nesting turtles in regulating the population size.

While egg destruction is an obvious feature observed on nights of dense turtle nesting at Raine Island, it represents an egg loss equivalent to only a small portion of the nightly egg production — certainly in the early to middle part of the nesting season. There is a large net gain in eggs to the beach each night during the nesting season. This turtle induced egg mortality in low to medium nesting density years at Raine Island is smaller than the 33-44% mortality of Bramble Cay *C. mydas* eggs which are lost through erosion each summer (Parmenter, 1980b; Limpus et al., 2001). In Surinam, Schulz (1975) estimated that *C. mydas* egg mortality from flooding and erosion of nests was 30%, 38% and 44% in each of the 1971, 1972 and 1973 breeding seasons respectively. High egg mortality would appear to be a natural feature of at least several widely scattered *C. mydas* rookeries which are functioning at very different nesting densities.

HATCHLINGS

Hatchling *C. mydas* were only examined in detail from Raine Island. These hatchlings were typical for the species with dark brown to black dorsal colours and white ventrally. Dorsally the trailing margin of the flippers and the carapace margin were edged in white.

HATCHLING SIZE. There was no significant difference in hatchling straight carapace length (SCL) among the annual samples of freshly emerged hatchlings (Mean hatchling SCL = 4.86cm) (Table 36). There were significant differences in hatchling weight among the annual

TABLE 37. Frequency distribution scute pattern on hatchling *Chelonia mydas* from Raine Island. * All costal and vertebral variability and most of the remaining variability occurred in one clutch. # 3 hatchlings from one clutch sample each with 2 small scutes between the pair of prefrontals = inter-prefrontal scutes. One hatchling from another clutch with an intervertebral scute between 1st and 2nd vertebral scutes. ** preocular scales were not counted with all clutches.

		1978 Dec	1979/80	1983 April	1984 April	Total
Clutches examined		1	6	10*	46	63
Scute	Scute count	Frequency				
Nuchal	1	8	57	100	457	622
	2				3	3
Vertebral	5	8	52	97	441	598
	6		3	3	14	20
	7		2		4	6
	8				1	1
Post-vertebral	1/1	8	57	98	450	613
	1/2			2	4	6
	2/2				6	6
Costal	4/4	8	53	97	450	608
	4/5		1		2	3
	5/4			2	4	6
	5/5		2	1	4	7
	5/6		1			1
Marginal	10/11			1		1
	11/10				1	1
	11/11	8	57	99	453	617
	12/12				5	5
	13/13				1	1
Postoccular	1/1				1	1
	3/3		5	1	14	20
	3/4	1	3	2	6	12
	4/3		2	1	10	13
	4/4	6	35	80	336	457
	4/5		3	4	40	47
	5/4		4	9	35	48
	5/5	1	5	2	18	26
	6/5			1		1
Preocular**	0/0	-	57	100		157
Prefrontal	2	8	57	100#	459	624
	1				1	1
Post-parietal	1				2	2
	2	8	54	14	372	448
	3		3	16	71	90
	4			69	14	83
	5			1	1	2
Infra-marginal	3/3				2	2
	3/4		1		3	4
	3/5		1			1
	4/3			2	5	7
	4/4	8	54	97	435	594
	4/5			1	1	2
	5/4		1		9	10
	5/5				5	5

samples (Mean hatchling weight = 23.80g) (Table 36). The size of the hatchlings varied significantly between clutches within each breeding season (Table 36). The inter clutch differences in hatchling weights may reflect varying degrees of desiccation of the hatchlings as they dig their way from the nest to the beach surface.

For a sample of 100 hatchlings from ten clutches, there was a significant log-log correlation between straight carapace length and weight: $\log_{10}wt = 1.446 \log_{10}CCL - 1.046$ (wt in g, CCL in cm; $r^2 = 0.607$, n = 100 hatchling, $p<0.001$).

These hatchlings were very similar in size to emerged *C. mydas* hatchlings from Bramble Cay in 1978/79 (mean SCL = 4.85cm; mean wt = 23.23g; Parmenter, 1979) and from Heron Island in 1974/75 (mean SCL = 4.97cm, mean wt = 24.83g; Limpus, 1980b) and in 1980/81 (mean SCL = 4.89cm, mean wt = 24.93g; Limpus et al., 1984a). *C. mydas* hatchlings from both the northern and southern GBR are similar in size and collectively are near the middle of the size range for hatchlings worldwide (Hirth, 1980).

HATCHLING SCALATION. The variability in hatchling scute pattern is summarised in Table 37. The modal scute pattern of the Raine Island *C. mydas* hatchlings was typical of the species: 1 nuchal, 5 vertebrals, 1/1 post vertebrals, 4/4 costals, 11/11 marginals, 4/4 postocculars, 0/0 preocculars, 2 prefrontals, 2 post parietal, 4/4 inframarginals (Pritchard, 1979).

INCUBATION AND EMERGENCE SUCCESS. In assessing hatching and emergence success at Raine Island, no attempt was made to quantify the proportion of clutches that produced zero emergence of hatchlings to the beach surface. There is, therefore, no measure of total clutch failure for this rookery. Total clutch failure can result from erosion and flooding by high tides, from problems within the egg that are derived from the female herself and possibly from microbial infections. At Raine Island there is an additional problem of flooding by a rise in the water table below the island following rain, with very high tides or from storm wash over of the beach. For example: in April 1984, following heavy rain, the water table on the beach was above the sand surface in the lower parts of the beach depression (between the beach crest and the cliff) with pools of water lying scattered in the lower areas of the beach. Nests along this depression that contained eggs yet to hatch would have been flooded for several days. When turtle eggs are immersed in water for more than a few

TABLE 38. Hatching and emergence success of *Chelonia mydas* clutches that produced hatchlings to the beach surface at Raine Island.

	1979 June		1983 April		1984 April	
No. of clutches	37		16		162	
Hatchlings						
Emerged from nest	2814	74.37%	1278	82.77%	13115	78.35%
Live in nest	7	0.18%	16	1.04%	78	0.47%
Dead in nest	13	0.34%	11	0.71%	81	0.48%
Eggs						
Unhatched	256	6.77%	142	9.20%	1328	7.93%
Undeveloped	669	17.68%	94	6.09%	1942	11.60%
Predated by crabs	25	0.66%	3	0.19%	195	1.16%
Total	3784		1544		16739	

minutes they drown. Fig. 40 illustrates the flooding of eggs by an elevated water table in February 1997. That February visit to Raine Island followed one of the largest recorded December nesting populations, so it was expected that vast numbers of hatchlings would be crossing the beach daily. Instead, only tens to low hundreds of *C. mydas* hatchlings were crossing the beach nightly. In response to this unexpected low hatchling production, 93 holes were dug to nest depth at random locations within each habitat type and each 100m sector around the beach platform. Dead turtle eggs in situ in nests were encountered in every hole. No live eggs were found in any hole. It is highly likely that only a trivial proportion of the eggs laid on Raine Island during the massed nesting season of 1996/97 produced hatchlings.

Since 1996, flooding of much of the nesting habitat during the mid nesting season has been a regular event. Subsequent extensive flooding of the nesting habitat, as evidenced by the water table being visible in the bottom of body pits, occurred through at least early to mid December of 1998, 1999 (Figs 9, 10), 2000 and 2001. Eggs that were laid up to 8 weeks prior to these flooding events are expected to have drowned and failed to hatch. Only 1997 had a relatively dry early nesting season (Fig. 7) and should not have had the clutches subjected to this broad scale flooding.

Hatchling emergence in February-March which should originate from the peak period of nesting has only been evaluated in February 1997. Most hatching and emergence success data

FIG. 40. *Chelonia mydas* laying eggs into a water-filled egg chamber on the cliff top at the western end of Raine Island, early February 1997.

have been recorded from four samples of nestings from the latter part of nesting seasons. The hatching and emergence success are summarised in Table 39. There was a low proportion of eggs that showed no obvious embryonic development (6-18% of eggs laid) and a high proportion of hatchlings successfully emerged onto the beach surface (74-83% of eggs laid). Predation of eggs within the nests was low (0.19-1.16%) and could be attributed to predation by the ghost crab *Ceratophthalmus cordimana*, the only ghost crab, living in the supratidal habitats. These values apply only to clutches that produced hatchlings to the beach surface.

On four occasions, emerged clutches were dug to determine the proportion of clutches that had been laid into an existing clutch:

1979, 13-14 December: of 38 emerged clutches dug, 1 was a clutch on top of another and both these clutches had a high hatching success. Only one of the 38 clutches contained yolkless eggs.

1980, 8-24 June: of 78 emerged clutches dug, 3 were clutches that had been laid into an existing clutch and in each case both the clutches had a high hatching success.

1983, 24-29 April: of 18 emerged clutches dug, 2 were clutches that had been laid into an existing clutch and in each case both the clutches had a high hatching success.

1984, 3-25 April: of 162 emerged clutches dug, no clutch had been laid into an existing clutch.

These observations indicate that the eggs remaining in disturbed clutches can have a comparable hatching success to those in undisturbed clutches.

Emerging hatchlings dug to the surface from nests that had a mean depth of 80.6cm (SD = 9.073, range = 44-102, n = 200). This nest depth

TABLE 39. Hatching and emergence success data (Table 38) from *Chelonia mydas* clutches at Raine Island reanalysed on a clutch by clutch basis.

	Mean	SD	Range	n
1979: June (37 clutches)				
Clutch (counted at emergence)	102.27	22.345	68-168	37
Emerged hatchlings per clutch	76.05	30.305	1-149	37
Live hatchlings in nest	0.19	0.462	0-2	37
Dead hatchlings per nest	0.35	0.538	0-2	37
Unhatched eggs per clutch	6.92	9.867	0-41	37
Undeveloped eggs per clutch	18.08	15.004	1-55	37
Crab predated eggs per clutch	0.68	2.028	0-10	37
Hatching success (%)	74.45	23.137	1.17-99.0	37
Hatchling emergence success (%)	73.90	23.184	1.17-99.0	37
Nest depth (cm), bottom	76.64	7.407	65-96	33
1983: April (16 clutches)				
Clutch (counted at emergence)	96.50	25.458	46-139	16
Emerged hatchlings per clutch	79.88	25.458	46-139	16
Live hatchlings in nest	1.00	1.317	0-3	16
Dead hatchlings per nest	0.69	1.352	0-5	16
Unhatched eggs per clutch	8.88	8.484	0-31	16
Undeveloped eggs per clutch	5.88	7.822	0-32	16
Crab predated eggs per clutch	0.19	0.544	0-2	16
Hatching success (%)	85.52	13.139	45.68-100.0	16
Hatchling emergence success (%)	83.92	13.352	44.82-100.0	16
Nest depth (cm), bottom	79.73	6.638	65-90	15
1984: April (167 clutches)				
Clutch (counted at emergence)	103.33	19.568	37-155	162
Emerged hatchlings per clutch	80.96	21.600	18-139	162
Live hatchlings in nest	0.48	1.035	0-8	162
Dead hatchlings per nest	0.50	2.622	0-31	162
Unhatched eggs per clutch	8.20	7.846	0-53	162
Undeveloped eggs per clutch	11.99	12.882	0-91	162
Crab predated eggs per clutch	1.20	2.735	0-18	162
Hatching success (%)	79.58	14.958	20.43-100.0	162
Hatchling emergence success (%)	78.62	15.205	19.35-100.0	162
Nest depth (cm), bottom	81.55	9.400	44-102	152

was not significantly different to the nest depth recorded at laying ($t>0.2$) (Table 33).

The high emergence success of non disturbed and non inundated *C. mydas* eggs incubate at Raine Island (Table 39) indicate that they do not suffer from the very high level of microbial induced mortality associated with the high density *Lepidochelys olivacea* rookeries of Pacific Costa Rica (Cornelius 1986). The limited data suggest that the hatchling emergence from undisturbed nests will be very similar to that of the low density *C. mydas* rookeries elsewhere in the GBR, at Bramble Cay in 1978/79 (72.1%, n =31; Parmenter, 1979) and at Heron Island in 1966/67 and 1967/68 (87.9%, n = 26; 84.9%, n = 40 respectively; Bustard, 1976). Similarly the hatching success of the undisturbed Raine Island clutches was comparable to the hatching success recorded for Heron Island *C. mydas* clutches in 1980/81 (mean = 90.2%, n = 60; Limpus et al., 1983c).

HATCHLING PREDATION. 1975, 28 February-4 March: A typical day's observation of hatchling emergence and predation was as follows:

4 March. 1500hr almost no hatchlings were crossing beach. 1515hr, immediately following the mid afternoon heavy rain shower, large numbers of hatchlings were observed crossing the beach and entering the flat calm sea. Bird predation was intense at this time. Sharks and large fish were very obvious as they broke the smooth sea surface while feeding on the hatchlings streaming away from the island. The sharks were mostly *Carcharhinus* spp. (black-tipped whalers and grey whalers) the largest of which were in excess of 2m in length. The fish were mostly trevally, *Caranx* sp. By 1630hr there was again intense sunlight and few hatchlings were crossing the beach. From 1730hr onwards, even though there was only scattered cloud, abundant hatchlings were crossing the beach. Vast numbers of hatchlings were crossing the beach throughout the night into the hours approaching dawn. Approximately no hatchlings were crossing the beach during the mid morning hours the following day.

Predation by birds: Rufous night herons were scattered around the beach late in each afternoon and were observed regularly to pick up *C. mydas* hatchlings. Some were eaten on the beach but others were carried away. Regurgitated *C. mydas* hatchlings were seen at rufous night heron nests containing unfledged chicks. Crested terns were observed on four instances to pick *C. mydas* hatchlings from the water and on three instances to take hatchlings from the beach. In each case the hatchling was subsequently dropped and no further attempt to recover the hatchling was made by the bird. The regurgitated remains of *C. mydas* hatchlings were adjacent to numerous crested tern nests on Moulter Cay (5 February). None of the other species of birds (King, 1986) that were numerous around the island during these mass daylight emergences of

TABLE 40. Observed predation of *Chelonia mydas* hatchlings during emergence from the nest and the beach crossing phase at Raine Island during 4-7 April 1984. * denotes avian predators did not approach the nest, probably because of its close proximity to the bird hide and most hatchlings reached sea. The numbers of hatchlings that successfully reached the water are shown in parenthesis.

Date	Clutches examined				
	No. of clutches	Predation on hatchlings crossing beach			Not quantified
		100%	0%	Part of clutch	
4th	15	10	1 (104)	3 (87)	1*
5th	10	10	0	0	
6th	25	21	0	3 (75)	1*
7th	19	8	0	9 (84)	2
Total	69	49	1 (104)	15 (246)	4

hatchlings were observed to show any interest in the hatchlings. Even the larger species of sea birds present (brown, red- footed and masked boobies, lesser and greater frigatebirds, red-tailed tropicbirds) were not predators of the hatchlings.

Attraction of hatchlings to lights: When the deck lights of boat anchored adjacent to the western end of Raine Island reef were left on after dark, there was a dense carpet of hatchlings across the smooth water surface in the illuminated area within minutes. The hatchlings did not swim from the illuminated area but swam back and forth within it. Large numbers of fish and shark could be seen preying on the hatchlings. The light acted as a trap, holding the hatchlings in a dense concentration, and made them easy prey for the fish. When the lights were switched off the hatchlings dispersed away from the island out into the open sea. A *Carcharhinus* sp. (~150cm long) caught on the western reef edge at 2100hr had a stomach content of 17 *C. mydas* hatchlings, ranging from well digested to still alive.

1978, December: A small crocodile, *Crocodylus porosus*, was captured on the reef flat (Limpus, 1980c). This crocodile was using the island as a basking site by day and appeared to be foraging along the beach margin at night. Its stomach contained no food.

1980, 8-13 December: Ghost crabs, *Ocypode ceratophthalmus* and *O. cordimana* were abundant along the water line at night. Both were observed preying on the hatchling *Chelonia mydas*. Several of the small grey terrestrial hermit crab, *Coenobita* sp., were present but they were not observed to prey on turtle hatchlings.

1984, April: Rufous night herons were observed daily and nightly on the beach throughout the visit.

These were observed aggregating around nests and preying on the hatchlings as they emerged from the nests (Fig. 41). Example predation case histories:

1) At 1745hr on 7 April, 113 rufous night herons were observed in the vicinity of one nest with 58 of them

FIG. 41. Rufous night heron, *Nycticorax caledonicus*, preying on a *Chelonia mydas* hatchling at Raine Island, April 1983.

crowded at the nest site. These birds were observed to eat 67 *C. mydas* hatchlings from this nest. The hatchlings were taken as they emerged from the nest to the beach surface or, for hatchling just below the sand surface and wriggling to disturb the beach surface, the herons stabbed down to grasp and pull the hatchling from the nest. The herons carried the turtle hatchlings from the nest site and away from other birds before swallowing them whole.

2) On 11 April, observations over the southeastern beach commenced at 1600hr. A group of 15 rufous night herons was present . Other birds in the vicinity included common noddy, lesser frigatebird, silver gull, ruddy turnstone, Australian ibis, crested tern. 1620hr 25 rufous night herons present; 1650hr 9 rufous night heron present. 1710-1715hr, *C. mydas* clutch emerged with 50 hatchlings taken by rufous night herons and 1 by a crested tern. Herons were coming and going during the hatchling emergence and 39 were still present after the hatchlings ceased emerging.

HATCHLING PREDATION RATES DURING THE BEACH CROSSING. Hatchling predation was quantified at two periods of different densities of rufous night heron at Raine Island.

During April 1984, thousands of rufous night herons were breeding at the island with chicks in the nests. The number of clutches of *C. mydas* hatchlings emerging per 24hr period was counted on 13 days during 3-25 April 1984. The mean daily number of clutches of hatchlings emerging was 20.5 (SD = 5.18, range = 14-32, n = 13). Over four days and nights, 4-7 April, predation of *C. mydas* hatchlings during the beach crossing up to their entry to the sea was quantified for as many clutches as possible. The results are summarised in Table 40. From this sample, 350 hatchlings reached the sea from 69 clutches (assuming clutch count = 102, emergence success = 78.4%) (Table 39). This is equivalent to a hatchling survivorship while crossing the beach to the point of entry to the sea = 6.7%. Almost all of the associated predation was by rufous night herons.

During June 1980 there were only hundreds of rufous night herons on Raine Island and none were breeding. Few birds aggregated on the beach to prey on the hatchling turtles. Estimates of predation rates were made by direct observation and by examination of tracks on the beach for hatchlings emerged from 11 clutches: no predation for 5 clutches; crabs took 1 hatchling per clutch from each of 5 clutches (*Ocypode cordimana* identified at two of the hatchlings); an unidentified bird took 1 hatchling from 1 clutch. From these 11 clutches (assuming clutch count = 102, emergence success = 74%) (Table 39), the 6 hatchlings preyed upon during the beach crossing represent a hatchling survivorship during the beach crossing = 99.3%.

TABLE 41. Field data based on flipper tag recognition of female turtles within the internesting habitat tagged while nesting at Raine Island. These data were used to calculate Petersen estimates with Bailey's correction of the number of breeding *Chelonia mydas* present (N) in the internesting habitat of Raine Island Reef during December in successive breeding seasons. M = total number of marked turtles in the population; m = number of marked turtles recaptured in the adjacent waters out of a sample of n turtles examined for marks.

Date	Transect type	Marking	Days since marked	M	m	n	Estimate N ± SE
4/12/77	snorkel	Monel tag, L1	1	37	1	12	241 ± 128
6/12/77	snorkel	Monel tag, L1	1-2	49	1	16	417 ± 226
4/12/78	speedboat	Monel tag, L1	1-3	496	8	79	4,409 ± 1,313
4/12/81	speedboat	Monel tag, L3	1-27	2,421	34	197	13,696 ± 2,071
2/12/84	snorkel	Titanium tag, L3	1-11	1,765	1	83	74,130 ± 42,286
3/12/84	snorkel	Titanium tag, L3	1-12	2,034	7	127	32,544 ± 12,732
8/12/84	speedboat	Titanium tag, L3	1-17	2,104	7	91	24,196 ± 7,665
17/12/84	snorkel	Titanium tag, L3	1-26	2,362	2	44	35,430 ± 17,114
19/12/84	snorkel	Titanium tag, L3	1-28	2,475	6	97	34,650 ± 11,805
9/12/85	snorkel	Titanium tag, L3		1,385	4	10	3,047 ± 919
16/12/85	SCUBA	Titanium tag, L3		1,765	4	10	3,883 ± 1,171

The rufous night heron breeds on Raine Island in large numbers during the main period of hatchling emergence. It may require some 20-30 clutches of hatchlings to satiate these birds each evening/night. When there are hundreds or thousands of turtle clutches emerging nightly, the birds will make little impact on the hatchling numbers. However, when there are few clutches emerging, most of the hatchlings may be eaten before they reach the water. Outside the rufous night heron breeding season these birds are minor predators of the turtle hatchlings. This seasonality of intense predation by this nocturnal bird species on turtle hatchlings is a similar to that observed with the rufous night heron predation on *N. depressus* hatchlings on the beach at Crab Island (Limpus et al., 1983b).

These observations suggest that the most productive seasons with respect to hatchling survival during the beach crossing to the sea will be the dense nesting seasons. No attempt has been made to quantify predation of hatchlings after they entered the sea or to determine where they swim after they disperse from Raine Island Reef.

ESTIMATION OF THE ANNUAL RAINE ISLAND NESTING POPULATION SIZE

At present, the only precise method for measuring the total annual nesting population at a turtle rookery is via a total tagging census. This requires every female using the rookery to be tagged or checked for existing tags on every night of the five months or more of the nesting season. The remoteness of Raine Island makes it logistically and financially difficult to monitor an entire breeding season. In addition, the usually large size of the nesting population also makes it very difficult to tag every turtle present on any one night at mid season.

From repetitive total tagging censuses of the Heron Island *Chelonia mydas* rookery (Limpus, unpubl. data) and the Mon Repos *Caretta caretta* rookery (Limpus, 1985) it can be established that the nesting density at a standard sampling time within the mid nesting season can be used as an index of the size of the annual nesting population. However, it would be an advantage if the absolute size of the nesting population could be estimated from population sample data recorded at the island.

PETERSEN ESTIMATE. To reduce the problem of widening confidence limits that result from multiplying several factors, each with their own 95% confidence limits, a tagging - recapture method was used to relate the number of nesting turtles ashore on the island directly to the number of turtles swimming in the internesting habitat surrounding the island (see Methods). This method provides a single step calculation for estimating the number of female turtles within the nesting habitat.

The flipper tagging and transect data used to calculate the Petersen estimates with Bailey's

TABLE 42. Data recorded during estimation of the size of the annual Raine Island *Chelonia mydas* nesting population. The turtles were marked with paint on the carapace. Different colours or markings were applied on different nights within a breeding season. The number of adult female *Chelonia mydas* in the waters adjacent to Raine Island was estimated using a Petersen estimate, with Bailey's correction.

Painting on beach			Counts by speedboat transects							*C. mydas* Population estimate
			Counts of adult female *C. mydas*				Counts of non 'adult females'			
							C. mydas			
Date	No. painted (M)	Paint code	Date	Paint code	Total Short-tailed Adult-sized (n)	Painted (m)	Long-tailed adult	Immature sized	*E. imbricata*	
1987: coloured oil-based paint			Speedboat transects							
30/11/87	441	Yellow	1/12/87	Yellow	217	10	0	0	0	8,740 ± 2,458
1/12/87	241	Blue	2/12/87	Yellow	55	1	0	1	0	12,348 ± 7,001
2/12/87	838	Red	2/12/87	Blue		2				4,499 ± 2,188
3/12/87	542	Blue-green	3/12/87	Yellow	184	3	2	1	0	20,396 ± 9,022
			3/12/87	Blue		0				-
			3/12/87	Red		5				25,838 ± 9,606
			4/12/87	Yellow	327	3	3	2	0	36,162 ± 16,073
			4/12/87	Blue		0				-
			4/12/87	Red		5				45,811 ± 17,156
			4/12/87	Blue-green		0				-
			5/12/87	Yellow	356	3	3	1	0	39,359 ± 17,503
			5/12/87	Blue		0				-
			5/12/87	Red		12				23,013 ± 6,037
			5/12/87	Blue-green		0				-
			SCUBA							
			1/12/87	Yellow	376	7	0	0	0	20,782 ± 6,853
			2/12/87	Yellow	56	2	0	0	0	8,379 ± 4,078
			2/12/87	Blue		0				-
			3/12/87	Yellow	239	2	0	6	0	35,280 ± 17529
			3/12/87	blue		0				-
			3/12/87	red		6				28,731 ± 10,009
1988: white oil-based paint			Speedboat transects							
30/11/88	402	Stripe	1/12/88	Stripe	402	19	9	1	0	1,970 ± 384
1/12/88	237	Cross	2/12/88	Stripe	147	8	8	1		6,611 ± 2,026
6/12/88	289	V	2/12/88	Cross		0				-
			3/12/88	Stripe	161	8	0	0	0	7,236 ± 2,224
			3/12/88	Cross		2				12,798 ± 6,339
			7/12/88	Stripe	130	7	0	0	0	6,582 ± 2,126
			7/12/88	Cross		3				7,762 ± 3,418
			7/12/88	V		5				6,310 ± 2,330
			SCUBA							
			1/12/88	Stripe	19	4	0	0	0	1,608 ±569
			3/12/88	Stripe	46	3	0	0	0	4,724 ± 2,021
			3/12/88	Cross		2				3,713 ± 1,796
			7/12/88	Stripe	23	1	0	6	0	4,824 ± 2,667
			7/12/88	Cross		1				2,844 ± 1,572
			7/12/88	V		0				-
1991-2002: Transects standardised to boat transects										
6/12/91	950	Stripe	7/12/91	Stripe	435	30	0	0	0	13,361 ± 2,276
8/12/91	600	V	9/12/91	Stripe	543	18	0	2	0	27,200 ± 5,975
			9/12/91	V		2				108,800 ± 54,250

TABLE 42 (*Cont.*)

Painting on beach			Counts by speedboat transeets							*C. mydas* Population estimate
			Counts of adult female *C. mydas*				Counts of non 'adult females'			
							C. mydas			
Date	No. painted (M)	Paint eode	Date	Paint code	Total Short-tailed Adult-sized (n)	Painted (m)	Long-tailed adult	Immature sized	*E. imbricata*	
1991-2002: Transeets standardised to boat transeets (eont.)										
1992/93	Sea too rough to make counts									
1993/94	Sea too rough to make counts									
1994/95	Sea too rough to make counts									
1995-2002: Paint standardised to Airpave™										
6/12/95	1,010	Lengthwise	7/12/95	Lengthwise	1,039	24	21	0	1	42,016 ± 8,140
1/12/96	1,033	Lengthwise	2/12/96	Lengthwise	194	6	-	-	-	28,776 ± 9,990
7/12/96	1,526	Crosswise	8/12/96	Crosswise	489	28	-	-	-	25,784 ± 4,566
1/12/97	553	Lengthwise	2/12/97	Lengthwise	145	3	2	3	0	21,290 ± 9,397
1998/99	Sea too rough to make counts									
8/12/99	1,239	Lengthwise	9/12/99	Lengthwise	3,261	50	4	13	0	79,247 ± 10,903
10/12/99	1,147	Crosswise	11/12/99	erosswise	3,812	55	0	8	0	78,098 ± 10,268
4/12/00	86	Lengthwise	5/12/00	Lengthwise	39	2	2	0	0	1,147 ± 551
7/12/00	96	Crosswise	6/12/00	Lengthwise	30	2	1	0	0	889 ± 422
			7/12/00	Lengthwise	54	5	0	1	0	788 ± 281
			8/12/00	Lengthwise	40	3	0	0	0	882 ± 374
			8/12/00	Crosswise		0				-
6/12/01	1,188	Lengthwise	7/12/01	Lengthise	1,024	8	1	3	0	135,300 ± 42,597
8/12/01	1,163	Crosswise	9/12/01	Crosswise	1,024	16	1	3	0	70,122 ± 16,390

corrcction of the number of adult female *C. mydas* in the waters surrounding Raine Island during early December, 1977-1985, are summarised in Table 41. While there is some variability in the results from within a single nesting season, the 95% confidence limits usually overlapped.

When the method was first used, it relied on the turtles being tagged distally on the trailing edge of the front flipper (L1 tagging position) with monel tags. These distally applied tags were highly visible (flashing in the sun light) on the swimming turtle in the clear shallow waters surrounding Raine Island. When the tagging position was changed from L1 to L3, the tag became more difficult to distinguish. The tag became even more diffieult to detect on a swimming turtle when the tag design changed, to improve tag retention, from the highly polished monel tag to the more dull lustred titanium tag. Under the latter circumstances many more turtles were being excluded from the underwater counts of tagged/untagged females because of uncertainty of recognising the presence/absence of a tag, especially during speedboat transects. This resulted in more time having to be spent counting turtles with divers/snorkelers in the water rather than using speedboat transeets. With the former came the increased frequency of encountering big tiger sharks.

In 1987 a system of paint tagging the nesting females was introduced (Figs 42-43) to increase the visibility of a tagged turtle in the water. The paint marks on the turtle carapaees held well for about 4 days following application. Some turtles were encountered back on the island after more than 4 days with most of the paint mark obliterated. Within the internesting habitat, most of the paint loss was caused by abrasion as turtles pushed into crevices under coral. The paint peeled off more readily if the carapace was not dry when painted or if there was an algal coat on the carapace. The different paint colours (Table 42) were not equally recognisable in the water. For example, no green painted turtles were 'reeaptured' swimming over the reef while all other colours were recognisable. This lack of recaptures was not because the green paint marks had been shed by the turtles. Green painted turtles were frequently encountered ashore on the island on subsequent nights. Blue paint was only marginally more visible than the green paint. From 1998 onward, the paint tagging has been standardised to white paint. White paint was very

FIG. 42. Paint tagging a nesting turtle at Raine Island, December 2000 as part of the Petersen Estimate of the size of the total nesting population.

FIG. 43. A paint tagged female (longitudinal stripe) in the internesting habitat of the reef margin to Raine Island Reef, December 2002. (Photo W. MacPharlane)

visible on the backs of the turtles in the water and contrasting paint mark designs were easily distinguished up to 30m underwater, even when the turtle was barely distinguishable at that distance. Since 1995, the paint tag has been the more durable outdoor paint designed for road marking. As it became apparent that very large sample sizes had to be marked and examined to provide estimates with tight confidence limits, the underwater transects swum with snorkel or SCUBA were phased out in favour of the speed boat transects. This also provided for reduced risk to the team given that large tiger sharks were regularly encountered during swim transects at Raine Island Reef.

A search of Raine Island Reef waters and the water of adjacent reefs during December 1988 demonstrated that turtles nesting at Raine Island were mostly concentrated in the waters immediately surrounding Raine Island and were not scattered widely throughout the region during the internesting intervals (Table 43).

Within any one sampling period, the population estimates obtained using carapacial painting to tag the nesting females were variable. When large numbers of nesting females were painted ashore at Raine Island and a very large sample (thousands) of the turtles examined in the internesting habitat on Raine Island Reef, there was usually reasonable agreement among the estimates of the internesting population size (Table 42). However, the results are probably influenced by sea surface conditions. Unfortunately, the weather is not always compatible with these types of studies and in at least 4 years the counts on the reef flat could not be undertaken because of the weather.

The relationship between the mean nightly tally count and the estimated size of the internesting population in the adjacent waters is illustrated in Fig. 44. For most years, the Petersen estimate has correlated well with the mean tally count. This has been particularly so for mean tally counts up to about 4,000 females per walk of the beach. At this mean tally count level, there is an estimated internesting population adjacent to the Raine Island rookery of approximately 25,000 breeding female *C. mydas*. The relationship is poor when there are very dense nesting populations. In particular, in the 1999

TABLE 43. Numbers of turtles recorded during speedboat transects over reefs adjacent to Raine Island, 4-6 December 1988. Only *Chelonia mydas* were identified during these transects. No painted turtles from Raine Island or from Moulter Cay were observed during these transects.

Date	Short-tailed		Long-tailed	Reef location (transect time)
	Adult sized	immature		
4/12/88	76	0	0	Moulter Cay (30 min)
5/12/88	1	0	0	11-093
	0	5	0	11-095
	1	0	0	11-096
	0	0	0	11-097
	0	0	0	McGillivray Cay (20 min)
6/12/88	2	0	0	Jukes Reef

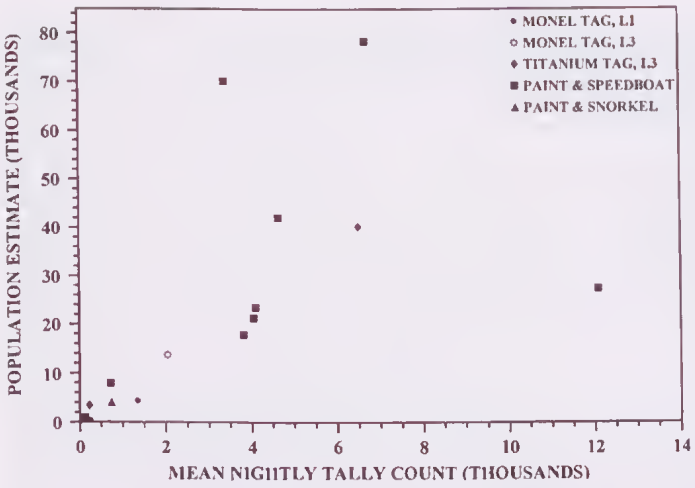

FIG. 44. Comparison of the Mean nightly tally count with the estimated number of adult females in the interesting habitat of Raine Island. The Petersen estimate was used to estimate the size of the interesting population. See text for description of the tagging and transect count methods.

season, the estimate of 78,672 ± 10,586 was not expected from the mean tally count of 6,693. However, this estimate would appear to be consistent with the exceptionally dense population of *C. mydas* photographed in the Raine Island internesting habitat in late 1999 (Chadwick & Doubilet, 2000). In the exceptionally dense nesting seasons, there could be approximately 80,000 females in the Raine Island internesting habitat in early December.

Estimating the size of the total annual nesting population for Raine Island via a single Petersen estimate calculation using data derived from marking on the nesting beach and 'recapture' in the internesting habitat in the days immediately following tagging is cost effective. The method warrants further investigation to improve its rigor in the very high density nesting seasons. Carapacial painting is a workable method for tagging the turtles, provided the paint marks are prominent and of a suitable colour. Selected colours and/or paint marks can be used to distinguish different tagging cohorts. To maximise the precision of the estimate, it is essential to maximise the proportion of the total population of internesting turtles tagged in any one nesting sample and to maximise the number of turtles examined in the aquatic recapture phase. In this regard, further investigation of the painting technique would be appropriate to develop a method for paint tagging many thousands of nesting females in a single night. At the same time the paint-retention time needs investigation to improve the capacity for pooling painted cohorts from different nights.

Within any one nesting season there will be different numbers of active nesting females present at different times of the season, with small numbers present in early and late season and maximum numbers present in mid season. From total tagging census studies at Bramble Cay in 1979/80, approximately 85% of the total annual nesting population visited the island during the last two weeks of December (Limpus et al., 2001). This should equate to the total population in the internesting habitat in early December. In addition, there is a strong correlation between the nightly number of nesting *C. mydas* using Moulter Cay (MCTALLY) (Table 4) with the nightly tally count Raine Island (RITALLY) (Table 3) on the same or adjacent night: MCTALLY = 0.3928 × RITALLY + 95 ($F_{1,14} = 47.6$; $p<0.005$. $r^2 = 0.773$, DF = 14.). By combining these two values it is possible to obtain an estimate of the size of the total annual nesting *C. mydas* at Raine Island, Moulter Cay and immediately adjacent islands:

= (Raine Is December estimate + Moulter Cay December estimate) / 0.85

= (RI December estimate + 0.3928 × Raine Is December estimate + 95) / 0.85

= 1.6386 × Raine Is December estimate + 112

Thus the estimated total annual nesting population for Raine Island and Moulter Cay in the very high nesting density seasons would approximate 131,000 females. The total nesting population in the extremely dense nesting seasons for the entire nGBR stock will be slightly higher if a few thousand additional females nesting at Bramble Cay, Murray Islands, No. 7 and No. 8 Sandbanks, Milman Island and the other *C. mydas* rookeries of the northern GBR and Torres Strait are added. A more typical dense nesting population with a mean tally count of about 4,000 females at Raine Island, may be in the order of 41,000 females breeding annually.

The nGBR stock, for which Raine Island - Moulter Cay are the primary breeding sites, supports the largest nesting aggregation of *C. mydas* remaining anywhere in the world (King, 1982; Groombridge & Luxmoore, 1989).

TABLE 44. Frequency distribution of the presence and absence of corpora albicantia on the ovaries of breeding adult female *Chelonia mydas* examined at Raine Island. The proportion of females with no corpora albicantia provides an estimate of the rate of recruit of new females into the breeding population (± 95% confidence limits).

Breeding season	Method of assessment	Nesting females examined			Recruitment	
		Total	With albicantia	Without albicantia	Estimated value	95% confidence limits
1989, Dec	Necropsy	98	85	13	13.3%	7.2-21.6%
1990, Dec	Necropsy Laparoscopy	8 52	59	1	1.7%	0.04-8.9%
1991, Dec	Necropsy Laparoscopy	29 50	77	2	2.5%	0.3-8.8%
1992, Dec	Necropsy Laparoscopy	2 97	93	6	6.1%	2.3-12.7%
1993, Dec	Necropsy	33	33	0	0%	-
1994, Dec	Laparoscopy	51	44	7	13.7%	5.7-26.2%
1995, Dec	Gonads sampled by non-standard method. Data deleted from analysis.					
1996, Dec	Necropsy	35	34	1	2.9%	9.9-14.8%
1997, Feb	Necropsy	100	100	0	0%	0.0-3.6%
1997, Dec	Necropsy	52	48	4	7.7%	2.1-18.5%
1998, Dec	Necropsy	1	1	0	-	-
1999, Dec	Necropsy	65	53	12	18.5%	9.9-30.0%
2000, Dec	No freshly dead turtles available during study.					
2001, Dec	Necropsy	16	14	2	12.5%	1.6-38.8%

ESTIMATION OF ADULT RECRUITMENT RATE

Ovaries of samples of breeding female *C. mydas* at Raine Island were examined for the presence or absence of corpora albicantia (Fig. 45). Corpora albicantia are ovarian scars from ovulations in previous years. Hence, females without corpora albicantia are in their first breeding season i.e. new recruits to the breeding population. The proportion of breeding females without corpora albicantia provides a measure of the recruitment rate of new adult females into the breeding population (Table 44). Commencing in 1989, an attempt was made to quantify the annual recruitment of new turtles into the Raine Island breeding population.

The annual recruitment rate of new adults into breeding population is low: mean = 7.17% (SD = 6.41, range = 0 – 18.5%, n = 11) (Table 44, Fig. 46).

These measurements are based on two underlying assumptions. 1) the rate measured on dead females at Raine Island is similar to the rate for the entire population, i.e. the nesting turtles that died on the island were a random sample of the entire nesting population with respect to recruitment. 2) that the recruitment rate measured in early December is representative of the entire breeding season. This assumption needs testing with *C. mydas* given that new recruit *C. caretta* and *N. depressus* tend to arrive later in the nesting season at south Queensland rookeries (C.J. Limpus and C.J. Parmenter, respectively, unpubl. data). This assumption was tested during the 1996 breeding season only and similar results were obtained in early December and early February (Table 44). Although the results from laparoscopy and necropsy provide no indication of a bias from the dead turtles (Table 44), this assumption warrants further testing.

There are few studies of marine turtles against which to judge the significance of these recruitment values. This recruitment rate for the Raine Island *C. mydas* is considerably lower than that estimated from tagging studies with *Caretta caretta* (30-50%, Natal, South Africa, Hughes, 1989; 30-40%, Georgia, USA, Richardson & Richardson, 1982; 44.2% ± 5.7%, Queensland, Australia, Limpus, 1985). However, all of these values for *C. caretta* have been measured in depleted populations. In contrast, the annual recruitment rate estimated from tagging

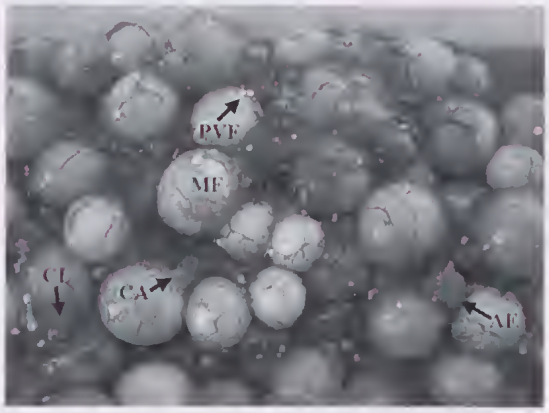

FIG. 45. An ovary with corpora albicantia. This ovary was from an adult female *Chelonia mydas* that died while ashore attempting to nest at Raine Island, December 2002. MF = mature ovarian follicle; AF = atretic follicle; PVF = pre-vitellogenic follicle; CA = corpus albicantium; CL = corpus luteum.

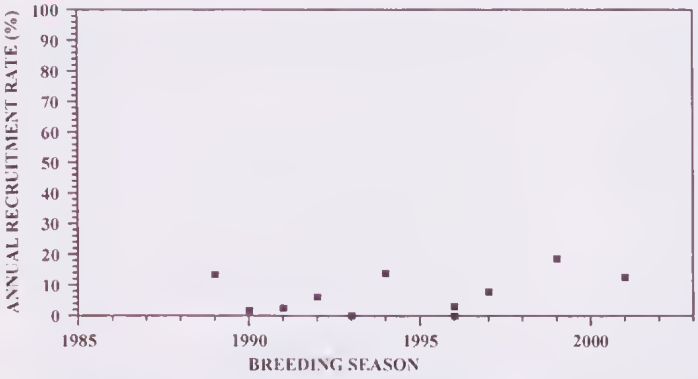

FIG. 46. Annual variability in recruitment rate of new females into the *Chelonia mydas* breeding population at Raine Island.

studies with the stable population of the eastern Australian *N. depressus* stockbreeding at Mon Repos, Peak Island and Wild Duck Island was in the range of 10-20% (Parmenter & Limpus, 1995; Limpus et al., 2002). The mean annual recruitment rate estimated from gonad examination using laparoscopy with the declining *E. imbricata* population the breeds in the northern GBR during 1991-2000 was 15.5% (SD = 6.65, range = 8.3 – 27.3%, n = 8) (Miller et al., 2000). Thus, the recruitment rate of new adults into the nGBR *C. mydas* stock is only slightly lower than the recruitment rate estimated for the stable population of *N. depressus* and the declining *E. imbricata* population that breed in eastern Australia.

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Annette Fleay, Valonna Baker, David Butler, Margaret Card, Michael Cassematy, Robyn Delaney, Carl, French, Matt Freher, Emma Gyuris, Mark Hamann, Brad Jones, Steven Neil, Mark Read, Darryl Reimer, Linda Rhineholdt and numerous volunteers collected data under the primitive field conditions on the islands. Brian King provided valuable team coordination for many study trips to Raine Island and worked in collaboration with us in documenting the significance of turtle nesting on the islands of the northern Great Barrier Reef.

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CONCLUSION

Raine Island has been a nesting site for green turtles for over 1,000 years. The nesting population of green turtles has been known to Europeans for approximately 175 years during which a navigation beacon tower was built, guano was mined and turtles were harvested. Green turtles nesting at Raine Island are part of a larger genetic stock that utilizes many islands in the northern Great Barrier Reef (nGBR) and eastern Torres Strait. This population is one of the largest remaining stocks for the species on a global scale. The nesting green turtles of the nGBR are morphologically similar to other genetic stocks of eastern Australia and the Gulf of Carpentaria, as well as elsewhere in the world. The population is chatacterised by a very long remigration interval with a mean of 4-5 years. The number of turtles using Raine Island varies by orders of magnitude among seasons. Fluctuations in numbers of nesting turtles are correlated with alterations in the ENSO measured 18 months preceding. Intra-annual variation also occurs; the highest density nesting occurs during the mid summer months and the lowest density nesting occurs during the winter months.

Adult mortality on the nesting beach and egg mortality were positively correlated, while predation by sharks on the nesting turtles and

nesting success were negatively correlated with an index of the size of the annual nesting population. In high density nesting seasons following repetitive disturbance females reduce the clutch production as a result of resorption of ovarian follicles. Death of nesting turtles is a natural phenomenon and occurs primarily from heat exhaustion on the beach by day following extended unsuccessful nesting attempts.

There has been a progressive decline in the size of nesting females over the decades of the study. This decline was associated with a decline in size of remigrant turtles. There was no decline in the size of turtles being tagged for the first time. The decrease in size of the females occurred in conjunction with a progressive increase in remigration interval. In recent times, the nesting population is also characterised by a very low recruitment rate. These demographic characteristics may indicate that this large population is in the early stages of decline as a result of loss of adult turtles. There is wide spread hunting of turtles from this population that preferentially targets the adult and near adult size (Schulz, 1984; Kwan, 1991; Johannes & MacFarlane, 1991) that could account for these changes. In addition, if the recent phenomenon of very low hatchling production resulting from flooding of the Raine Island nesting habitat continues, then significant declines can be expected in the numbers of young *C. mydas* in the dispersed foraging areas. Taken together, there is a high probability that this population will decline in the foreseeable future. It is recommended, that monitoring of the impact of human induced mortality on the population throughout it dispersed foraging areas be increased and that steps be taken to reduce human mortality to a sustainable level.

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AOUPINIA, A REMARKABLE NEW GENUS OF ADELIINI FROM NEW CALEDONIA (COLEOPTERA: TENEBRIONIDAE)

ERIC G. MATTHEWS

Matthews, E.G. 2003 06 30: *Aoupinia*, a remarkable new genus of Adeliini from New Caledonia (Coleoptera: Tenebrionidae). *Memoirs of the Queensland Museum* **49**(1): 441-445. Brisbane. ISSN 0079-8835.

Aoupinia pseudohelea, new genus and species, is described from Aoupinie Special Fauna Reserve, New Caledonia, where it occurs in rainforest leaf litter. Although strongly resembling the unrelated Australian tenebrionine *Helea* Latreille, *Aoupinia* belongs to the lagriine tribe Adeliini, a Gondwanan group which has diversified extensively in New Caledonia. There is an analysis showing that the new taxon belongs to a group of ten Australian and New Caledonian genera termed the northern squalid group, but that it is of uncertain relationship vis-à-vis particular genera within this group. ❐ *Coleoptera, Tenebrionidae, Adeliini, New Caledonia, new genus.*

Eric Matthews, South Australian Museum, North Terrace, Adelaide 5000, Australia (e-mail: matthews.eric@saugov.sa.gov.au); 27 August 2002.

New Caledonia has a diverse representation of the Gondwanan tribe Adeliini, which also occurs in Australia, New Zealand and Chile (Matthews, 1998). Kaszab (1982), in his revision of the Tenebrionidae of the island, described and keyed eight genera and 50 species of Adeliini, and 20 additional species were described after two subsequent visits there by G.B. Monteith of the Queensland Museum (Kaszab, 1986). While it was evident from the small number of known specimens of some taxa that the tenebrionid fauna of New Caledonia was still imperfectly known, it nevertheless came as a surprise to discover there a taxon of Adeliini which was completely different from any other member of the tribe, one which in fact bears a striking external resemblance to the unrelated Australian genus *Helea* Latreille.

A single specimen of this species was found in late 2000 in the Réserve Spéciale de Faune de l'Aoupinie by G.B. Monteith. This reserve straddles the 1000m Massif Central which forms the east/west divide in the centre of the island and is traversed by a road which crosses between Poya and Ponérihouen servicing a radio repeater station on the summit. In the following year three more specimens were found in the same place by the same collector.

SYSTEMATICS

Aoupinia gen. nov.

TYPE SPECIES: *Aoupinia pseudohelea* sp. nov.

DESCRIPTION. Oblong, castaneous, alutaceous, both dorsal and ventral surfaces squalid, covered with a thin layer of fine soil retained by numerous small, curved, thickened setae disposed over entire body and legs, not tuberculate.

Head. Clypeus with anterior edge convex, straight in middle. Clypeo-frontal suture deeply impressed. Frontal grooves present, distinctly impressed. Eyes strongly transverse, surrounded by a groove. Antennae not quite reaching base of prothorax, antennomeres (Fig. 3A) 1-7 more or less oblong or a little obconic, with sparse long setae, 3 as long as 4 and 5 combined, 7 1.5× as long as 6, 8-11 moniliform, paler and slightly wider than preceding segments, densely covered with very short setae as well as a few longer bristles. Mentum trapezoidal, depressed on basal and middle areas, a little raised anteriorly in middle. Terminal maxillary palpomere enlarged and securiform.

Prothorax. Pronotum with sides expanded into wide flanges which arch forward over head. Hind edge with 4 projections partly overlapping elytral bases. Prosternum long before coxae, its anterior edge raised into a prominent convex collar (Fig. 2, c). Prosternal process flat, moderately wide, slightly expanded posteriorly with almost straight hind edge.

Pterothorax. Elytral disc smooth, not tuberculate. A wide reflexed flange emerging along entire length of elytron just outside 8th stria. No epipleuron evident underneath, outside edge of elytron with narrow beading. Wings absent. Meso- and metaventrites as in Fig. 2.

Legs. Slender, femora and tibiae subparallel, densely covered with small curved setae holding a layer of soil, apical spurs very small.

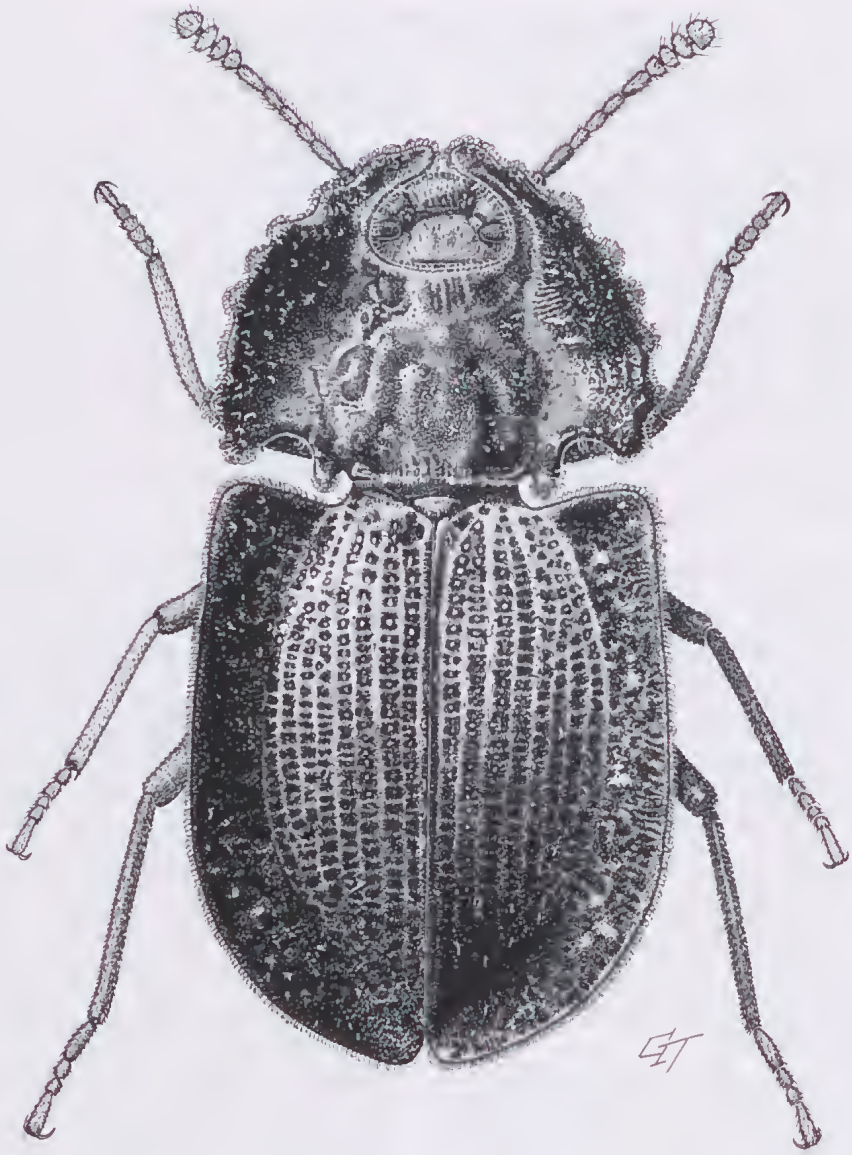

FIG. 1. *Aoupinia pseudohelea*, ♂.

Tarsomeres not expanded, obeonie or moniliform, densely and finely setose, penultimate tarsomere with outer face moderately oblique and only slightly prolonged into a small rounded lobe. Basal metatarsomere subequal in length to apical one.

Abdomen. Intercoxal process of first ventrite broadly rounded (Fig. 2). Tergite 7 without stridulatory files or thickened basal portion. Segment-7 glands absent. Very long extrusible glands emerging between segments 8 and 9. Ovipositor (Fig. 3C) with elongated and fused coxites 3 and 4, gonostyles terminal. Vagina without sclerites, with diverticulum (Fig. 3C) a cluster of a few spermathecal tubules (Fig. 3C) at base of aeeessory gland (ag).

Aoupinia pseudohelea sp. nov.
(Figs 1-3)

MATERIAL. HOLOTYPE: Museum National d'Histoire Naturelle, Paris: ♂, New Caledonia, Aoupinie top camp, 23 November 2001, GB. Monteith, QM Berlesate 1045,

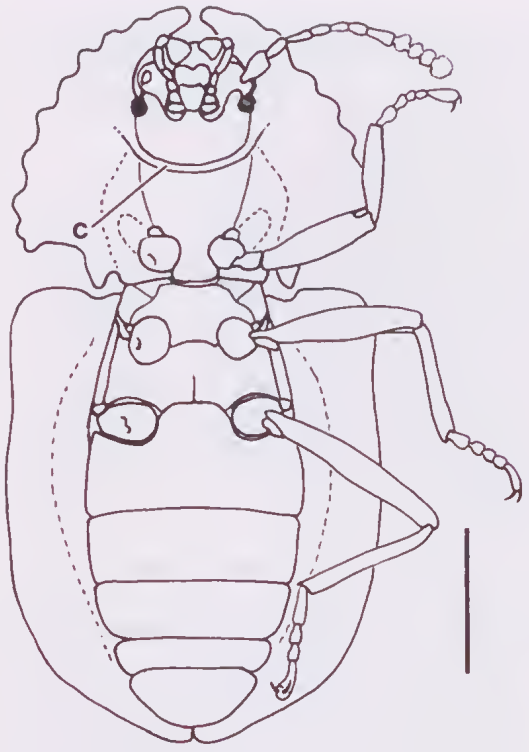

FIG. 2. *Aoupinia pseudohelea*, outline of underside. e, collar of prosternum. Scale = 2mm.

21°11'S 165°18'E, Rainforest 850m, Sieved litter. PARATYPES: All in Queensland Museum: 1 ♀: Same data as holotype (QMT93428); 1 ♂: Aoupinie, 20 Nov 2000, G.B. Monteith, QM Berlesate 1035, 21°11'S 165°19'E, Rainforest, 850m, Sieved litter (QMT93427); 1 ♀: Aoupinie top camp, 2-3 Nov 2001, G.B. Monteith, QM Berlesate 1060, 21°11'S 165°18'E, Rainforest, 850m, Sieved litter (QMT93426).

DESCRIPTION. Total length 9.8-11.0mm, maximum width across elytra 5.0-5.7mm.

Head. As for genus.

Prothorax. Disc of pronotum smooth and somewhat uneven, a little depressed in middle, with trace of median impressed line at base only, anterior edge concave, posterior edge straight in middle, each side expanded into a basally very wide upcurved flange with scalloped edges which narrows anteriorly to produce an extension arching forward over head, not quite meeting extension of other side (Fig. 1). Edge provided with a fringe of numerous closely-spaced short, curved and thickened setae. Hind edge of flange deeply arcuately excised outwardly with produced hind angle, inwardly with a strong

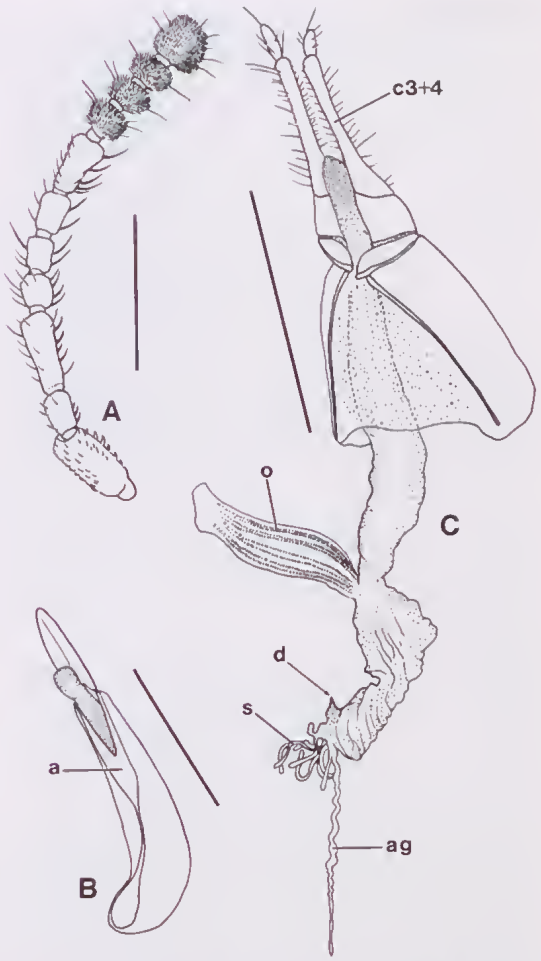

FIG. 3. *Aoupinia pseudohelea*. A, left antenna from below; B, aedeagus in ventral view; C, ovipositor and female tract in ventral view. a, fused alae of aedeagus; ag, spermatheeal accessory gland; c3+4, fused coxites 3 and 4; d, diverticulum; o, common oviduct; s, spermatheeal tubules. Scales = 1mm.

projection directed backward toward base of elytron, upper surface of flange feebly rugose and punctate.

Pterothorax. Discal surface feebly convex, intervals flat, striae consisting of closely spaced moderately impressed punctures, 8th stria at base of flange with larger and deeper punctures. Flanges wide, about 1/3 as wide as elytral disc, their edges even and provided with serried row of hooked setae, dorsally with numerous large shallow punctures not aligned into striae.

Legs. As for genus.

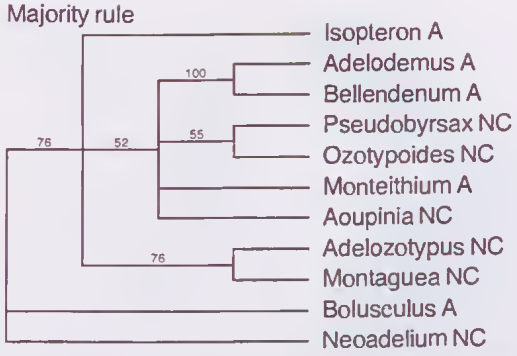

FIG. 4. 50% majority rule consensus of 33 trees for ten related squalid genera of Adeliini with *Neoadelium* as the outgroup, using PAUP 3.1. All characters unordered and unweighted. Tree length 54, CI 0.533. A = Australia; NC = New Caledonia.

Abdomen. Aedeagus (Fig. 3B) with sides of basal piece infleeted but not quite meeting, alae (Fig. 3B) membranous, fused, no basal flange. Otherwise as for genus.

HABITAT. *Aoupinia* was extraeted by Berlese funnel from sieved leaf litter collected in undisturbed rainforest at 850m altitude at the point on the summit of the range where the east and west aeeess roads meet. It is eurious that no other rainforest-inhabiting Adeliini were found in this area, apart from a speeimen of an undeseribed speeies of *Ozotypoides* Kaszab obtained by pyrethrum fogging of a tree trunk (G.B. Monteith, pers. comm.). Like all the squalid Adeliini *Aoupinia* is eovered in life with a layer of fine elay whieh presumably serves to make the beetle ineonspieuous, and whieh in this ease bridges the gap between the two wings of the pronotal flanges.

RELATIONSHIPS OF *AOUPINIA*

In spite of its elose resemblanee to *Helea*, whieh belongs to the Tenebrioninae, *Aoupinia* is shown to be in the Adeliini (Lagriinae) by the pair of long eversible defensive gland saes emerging between segments 8 and 9 of the abdomen. All other Tenebrionidae with defensive glands have them between segments 7 and 8 (and mueh shorter). Also, the ovipositor and female tract eonfiguration (Fig. 3C), with slender eoxites, terminal gonostyles, and multiple spermatheeal tubules, is typieal of Adeliini and unknown in Tenebrioninae.

Within Adeliini *Aoupinia* is strikingly different in appearanee from other genera beeause of its wide pronotal and elytral flanges with the former nearly meeting above the head, and its relatively large size. Nevertheless it is elear that it belongs to the group of northern rain forest genera informally ealled the *Pseudobyrsax* group by Matthews (1998), whieh ineludes all the New Caledonian squalid genera plus *Monteithium* Matthews of the Queensland wet tropies. This group is eharaeterised by a squalid integumentary surfaee (one whieh holds a layer of soil) whieh is also tubereulate in all members exeept *Aoupinia*, antennae with the apieal three or four segments eontrastingly tomentose (Fig. 3A), anterior edge of the prosternum often raised into a eollar (Fig. 2), epipleuron narrow throughout, presenee of a divertieulum on the vagina (Fig. 3C), and absenee of sexual dimorphism. It is a eharaeteristie of some

TABLE 1. List of eharaeters and their states.

1. Clypeus anterior edge: 0, straight; 1, emarginate.
2. Clypeo-frontal suture: 0, shallow; 1, deep.
3. Frontal grooves: 0, absent; 1, present.
4. Groove around eye: 0, absent; 1, present.
5. Eye shape: 0, transverse; 1, round.
6. Antennomere 7: 0, subparallel, a little longer than wide; 1, subparallel, 1.5-1.7 × as long as wide; 2, cupuliform.
7. Tomentose ('club') segments of antennae: 0, none; 1, three; 2, four.
8. Pronotal lateral outgrowths: 0, absent; 1, present.
9. Interlocking of fore and hind body: 0, absent; 1, present.
10. Prosternal collar: 0, absent; 1, present.
11. Prosternal process shape: 0, simple; 1, nodose; 2, bifureate.
12. Swollen metasternum: 0, absent; 1, present.
13. Elytral flange or earina along stria 8: 0, absent; 1, present.
14. Elytral intervals: 0, smooth; 1, tubereulate.
15. Epipleuron width: 0, widening anteriorly; 1, narrow throughout or not evident.
16. Penultimate tarsomere: 0, feebly or not lobed; 1, strongly lobed, symmetrieal; 2, strongly lobed, asymmetrieal.
17. Basal metatarsomere length: 0, shorter than or subequal to elaw segment; 1, longer than elaw segment.
18. Intereoxal process of first abdominal ventrite: 0, areuate; 1, truncate.
19. Stridulatory files of tergite 7: 0, present; 1, absent.
20. Vaginal selerites: 0, present; 1, absent.
21. Sides of aedeagal basal piece: 0, not meeting; 1, meeting.
22. Alae of aedeagus: 0, present, separate; 1, present, fused; 2, absent.

TABLE 2. Character state distribution for the northern squalid group with *Neoadelium* as outgroup. A = Australia, NC = New Caledonia.

	1 12345 67890	2 12345 67890 12
Neoadelium NC	00100 00000	00001 10011 12
Isopteron A	11010 00000	20000 00100 12
Bolusculus A	00100 00100	00111 00111 12
Adelodemus A	11100 00101	21010 11001 02
Pseudobyrsax NC	01010 02101	20011 10111 02
Adelozotypus NC	1 11110 01011	00011 00111 12
Montaguea NC	01110 01011	20011 00111 12
Ozotypoides NC	01010 12000	20011 10111 01
Bellendenum A	00100 00100	11010 21010 00
Monteithium A	00101 22101	21011 10110 01
Aoupinia NC	01110 12111	00111 00011 01

members of the group to interlock the fore and hind bodies by means of an interdigitation of integumentary projections and cavities, a feature which is maximally developed in *Montaguea* Kaszab. In *Aoupinia* there are similarly two backward inner projections on the prothorax (Fig. 1) which can be braced against the depressed part of the elytral bases.

In a previous analysis (Matthews, 1998) it was found that the intuitive *Pseudobyrsax* group is not clearly differentiated from the similarly squalid *Isopteron* group of four Australian genera, although the two together appear to be monophyletic and may be termed 'the northern squalid group' (there is an unrelated southern squalid group involving taxa from New Zealand, Chile and southeastern Australia). The northern squalid group is a syntaxon of five New Caledonian and five Australian genera, which is confined to the rainforests of northeastern Queensland and New Caledonia (with the single exception of the much more widespread Australian xerophilic *Isopteron* Hope). In New Caledonia the squalid genera have a very polarised distribution: of the five genera present, all occur in the northern half of the island while only one (*Pseudobyrsax* Kaszab) occurs in the southern half.

Here the 10 genera of the northern squalid group are briefly analysed again using PAUP 3.1, with *Aoupinia* and *Ozotypoides* Kaszab added to the previously included eight in Matthews (1998), and some additional characters introduced. The outgroup is the non-squalid, or carabiform, New Caledonian *Neoadelium* Carter which appears as a sister group in Matthews (1998, fig. 175). Table 1 lists the 22 characters involved and their states, and Table 2 shows the taxon character matrix. Autapomorphies (character states 5.1, 6.2, and 16.2) are included in the matrix even though uninformative in order to present a complete picture of character state distribution.

Intuitively it appears that *Aoupinia* is related to the Australian *Monteithium*, as suggested by the sharing of elaborate pronotal outgrowths and four tomentose antennal club segments, but in fact there are more numerous differences between the two as may be seen in the table. The resultant analysis (Fig. 4) leaves both these genera ungrouped either with each other or with any other single genus, while most of the remainder form a series of terminal pairs which are either wholly Australian or wholly New Caledonian. In other words, there is no suggestion of a closer relationship between any given Australian and New Caledonian taxa beyond that of their common membership in the northern squalid group as a whole.

ACKNOWLEDGEMENTS

I am grateful to Geoff Monteith of the Queensland Museum for giving me the opportunity to describe this extraordinary insect, latest in a long series of his discoveries in tropical rainforest. I also wish to thank Geoff Thompson of the Queensland Museum for the fine illustration of the whole beetle (Fig. 1), and the curators of the following collections for the loan of comparative material of New Caledonian Adeliini: Hungarian Natural History Museum (O. Merkl), New Zealand Arthropod Collection (R. A. Leschen), and Queensland Museum (G.B. Monteith).

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A NEW CAVERNICOLOUS SHRIMP IN *PYCNISIA* BRUCE, 1992 (CRUSTACEA: DECAPODA: CARIDEA: ATYIDAE) FROM NORTHWESTERN QUEENSLAND

HIROSHI SUZUKI AND PETER J.F. DAVIE

Suzuki, H. & Davie, P.J.F. 2003 06 30: A new cavernicolous shrimp in *Pycnisia* Bruce, 1992 (Crustacea: Decapoda: Caridea: Atyidae) from northwestern Queensland. *Memoirs of the Queensland Museum* **49**(1): 447-451. Brisbane. ISSN 0079-8835.

A new cavernicolous shrimp, *Pycnisia bunyip*, is described from Forbes Inferno Cave, Riversleigh, Lawn Hill National Park, northwestern Queensland. *Pycnisia* is differentiated from all other atyid genera by its robust pereiopods 3-4. *Pycnisia bunyip* is distinguished from the only known congener, *Pycnisia raptor* Bruce, by the shape of the rostrum and telson. This is the seventh species of troglophilic atyid from Australia. ❐ *Pycnisia, Atyidae, Caridea, Queensland, new species, troglobite.*

Hiroshi Suzuki, Aquatic Resource Science, Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan (e-mail: suzuki@fish.kagoshima-u.ac.jp); Peter J.F. Davie, Queensland Centre for Biodiversity, Queensland Museum, PO Box 3300, South Brisbane 4101, Australia; 15 April 2003.

The first Australian subterranean shrimp was described in 1960, and another five species have been described in indigenous *Stygiocaris* Holthuis, 1960, *Parisia* Holthuis, 1956, *Pycneus* Holthuis, 1986, and *Pycnisia* Bruce, 1992. All have so far been found only in wells or caves in northwestern Australia. These troglophilic shrimps have reduced eyes without pigments, and no carapace spines (except for an antennal spine in *Stygiocaris*). The previously monotypic *Pycnisia* was established for *P. raptor* because of its unique remarkably robust pereiopods. *Pycnisia bunyip* sp. nov. is the seventh species of troglophilic atyid from Australia.

Reproductive isolation leading to incipient speciation can be expected to occur amongst freshwater crustaceans occurring in widely isolated freshwater cave systems. During surveys of the Forbes Inferno Cave, Riversleigh, Lawn Hill National Park, northwestern Queensland, conducted in 1993 and 1994, unusual specimens of a *Pycnisia* species were found. The shape of the rostrum, and structure of the telson of these shrimps indicate that they represent a new species that is herein described and illustrated.

The types are deposited in the Queensland Museum, Brisbane (QM). Measurements are of post-orbital carapace length in millimeters (mm).

SYSTEMATICS

Family AYIDAE De Haan, 1849
Genus **Pycnisia** Bruce, 1992
Pycnisia bunyip sp. nov.
(Figs 1-4)

MATERIAL. Holotype: QMW26722, ♀ (7.0mm), Forbes Inferno Cave, Riversleigh, Lawn Hill National Park, northwestern Queensland, in shallow subterranean pools, S. Williams and B. Ehrlich, 22/6/1994. Paratypes: QMW26723, ♀ (2.6mm), data as for holotype. QMW26724, ♀ (specimen damaged), data as for holotype. QMW26725, ♀ (6.2mm,), same location, coll. S. Williams, 14/6/1993. QMW26725, ♀ (3.7mm,), data as for preceding specimen.

ETYMOLOGY. A mythical predatory creature said to live in Australian freshwater pools. A noun in apposition.

DIAGNOSIS. Rostrum small, short, reaching to only half length of eyes, but projecting beyond level of inferior orbital angle. Eyes reduced, pyriform, lacking pigment. Telson with one pair of dorsal spines (2 pairs in paratypes) and one pair of sub-dorsal spines, 7 spines (6-8 in paratypes) on posterior margin. Pereiopods 1-5 with 1, 1, 1, 1 and 2 setobranchs, respectively.

DESCRIPTION. Small species (postorbital carapace length <7.0mm), but largest recorded Australian troglophilic atyid species. Carapace thin, flexible, smooth, without spines or setae (Fig. 1); rostrum small, acute, with short, faint, dorsal ridge, reaching beyond level of inferior orbital angles to half length of eyes (Figs 1, 2A-B, 3M); pteryogstomian angle broadly rounded (Fig. 2B).

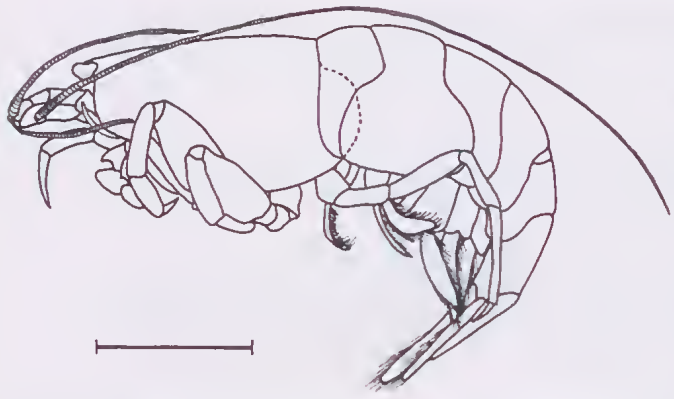

FIG. 1. *Pycnisia bunyip*, sp. nov., ♀ holotype (QMW26722), lateral view. Scale bar = 5mm.

Abdomen smooth, pleura of abdominal somites 1-5 rounded (Fig. 1). Telson slightly shorter than sixth abdominal somite, rectangular, with 1 pair of dorsal spines (2 pairs or 4 irregularly arranged dorsal telsonic spines on paratypes) and 1 pair of small subdorsal spines near posterolateral corner (Figs 2C, 3N,O); dorsal spines placed slightly behind middle of telson, second pair, if present, placed close to posterolateral margin (Fig. 3N,O); posterior margin broad, faintly biconvex, with 7 plumose and 5 simple setae (6-8 plumose setae in paratypes).

Eyes reduced, pyriform, devoid of pigment, cornea rounded (faint papilla on tip of eyes in small specimen with postorbital carapace length of 2.6 mm) (Figs 1, 2A-B, 3M).

Antennular peduncle stout, slightly exceeding distal margin of scaphocerite (Figs 2A, 3A,M); proximal segment broad, with stylocerite acute, laterally divergent, reaching beyond middle of proximal segment, outer anterolateral angle weakly forwardly produced (acutely produced in young paratype), medial margin relatively straight; intermediate and distal segments subcylindrical, medial margins setose; antennular flagella slender, subequal.

Antennal scaphocerite (Figs 2A, 3C,M) well developed, broad; outer margin with large broad acute distolateral tooth; inner margin convex; bluntly rounded distally; antennal peduncle (Fig. 3B) without spines; flagellum long (Fig. 1), distinctly longer than whole body length.

Mouthparts similar to *P. raptor*. Mandible without palp (Fig. 3D-E); molar process small, ocelusal surface with marginal setal fringe; incisor process short, broad, with 4 stout marginal teeth. Maxillula with slender palp, with several setae distally (Fig. 3F); upper lacinia narrow, with numerous short spinules on inner and distal margins; lower lacinia subrectangular with short setae on inner margin. Maxilla (Fig. 3G) with slender palp concealed behind endites, basal endite, coxal endite, and scaphognathite having 20 multidenticulate long setae on posterior end. First maxilliped (Fig. 3H) with simple tapered palp, not reaching to distal margin of basal endite; basal endite lamellar, elongate, medial margin densely fringed with setae; coxal endite stout; exopod well developed, caridean lobe large, broad, tapering distally; epipod vestigial. Second maxilliped (Fig. 3I) with well-developed exopod, with numerous long plumose setae on distal half, and shorter, thicker setae placed about quarter distance from base; small rounded epipod with multilamellar podobranch. Third maxilliped reaching beyond antennular peduncle, stout with small single arthrobranch (Figs 1, 3J); exopod well developed, with long setae distally; epipod strap shaped.

Pleurobranchs present on pereiopods 1-5, exopods on maxillipeds only, and epipods on all maxillipeds and pereiopods 1-4.

First pereiopod short, robust, chelate (Fig. 3K); chela about 1.5 × carpus length, palm of chela swollen, posteriorly expanded, longer than dactylus; fingers robust, tapering, curved, distally with tuft of sparse setae, claw-like tip; carpus expanded distally, distodorsal margin deeply excavate; merus subequal to chela, about 1.5 × carpus length, slightly broadened distally; coxa stout, with strap-like distally hooked epipod and one setobranch. Second pereiopod (Fig. 3L) with chela, chela about 0.9 × carpus length; palm feebly expanded proximally, faintly bowed; dactylus as long as palm length, unarmed, otherwise similar to first pereiopod; fingers subequal, stout, pigmented distally, fixed finger similar to dactylus; carpus feebly expanded distally, distodorsally feebly excavate; merus about 1.5 × carpus length; coxa similar to that of first pereiopod, with strap-like epipod and one setobranch. Third pereiopod very robust (Figs 2D, 4A); dactylus stout, tapering distally, unguis demarcated with fringe of setae, ventral margin with 9 stout, moveable spinules (Fig. 2E);

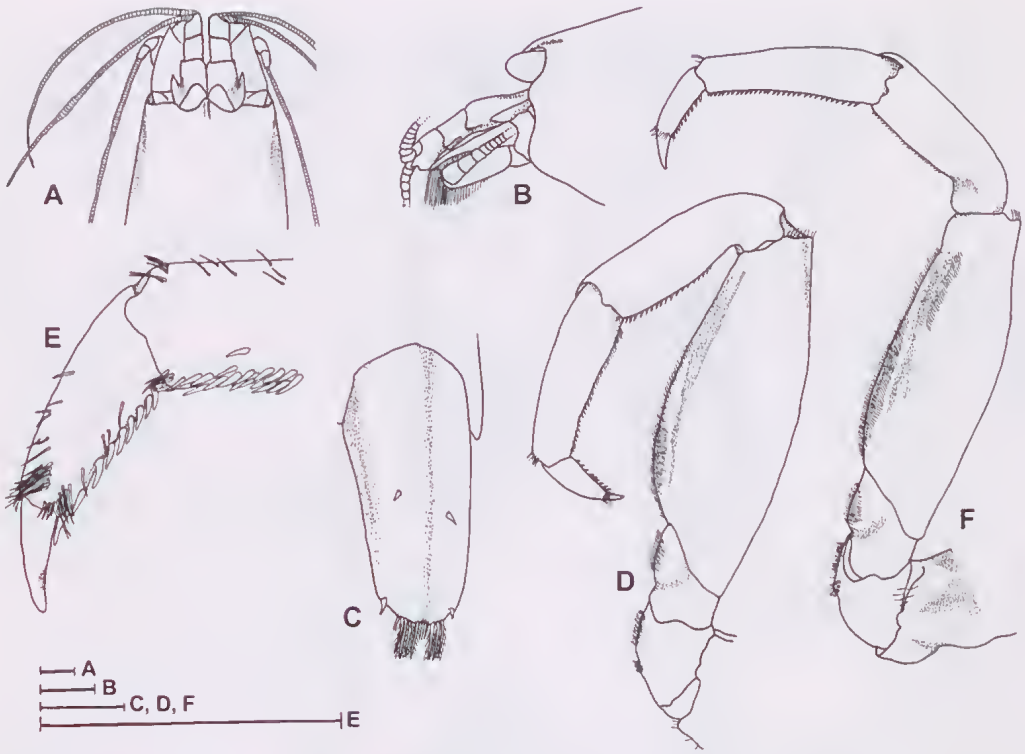

FIG. 2. *Pycnisia bunyip*, sp. nov., ♀ holotype (QMW26722): A, dorso-frontal view of carapace; B, latero-frontal view of carapace; C, dorsal view of telson; D, left third pereiopod; E, daetylus of left third pereiopod; F, left fourth pereiopod. Scale bars = 1mm.

propodus about 0.9× (range 0.8-1.1 in paratypes) carpus length, slightly bowed, ventral margin with numerous short, stout, moveable spinules; carpus slightly convex ventrally, with single row of setae medially; merus very robust, about 1.9× (range 1.9-2.7 in paratypes) carpus length, oval in section, 2.8× (range 3.8-5.0 in paratypes) longer than greatest width, dorsal and ventral margins convex; ischium short, distal half of ventral border with rounded patch of dense setae; basis short, robust; coxa robust, with strap-like distally hooked epipod and one setobranch. Fourth pereiopod (Figs 2F, 3B) robust as third pereiopod; propodus subequal to carpus (range 1.0-1.3 in paratypes); merus about 1.9× (range 2.0-2.9 in paratypes) carpus length, 2.9× (range 3.3-7.0 in paratypes) longer than greatest width; otherwise similar to third pereiopod. Fifth perciopod slender (Fig. 4C); dactylus slender, feebly tapering distally, unguis faintly demarcated; propodus about 1.7× (1.6 in paratype QMW26725) carpus length, ventrolateral border with row of stout setae; carpus with small distodorsal lobe; merus about 1.5× (1.7 in paratype QMW26725) carpus length; ischium and basis normal; coxa with two setobranchs but without epipod.

First pleopod (Fig. 4D) with slender, distally attenuated endopod. Second (Fig. 4E) to fifth pleopods similar, endopod not attenuated, with appendix interna. Uropodal protopod with posterolateral angle acute (Fig. 4F); diaeresis of exopod distinct, but incomplete; endopod slightly shorter than exopod.

Color In Life. Photographs show a yellow carapace with colour extending into anterior abdomen, probably representing the hepato-pancreas, and possibly ovary, beneath. Abdomen mostly transparent.

REMARKS. This new species, *P. bunyip*, is similar to *P. raptor* in having reduced eyes without pigmentation, a small rostrum, and robust pereiopods. However, in *P. bunyip* the rostrum reaches slightly past the level of orbital angle (shorter in *P. raptor*), and the telson has only one or two pairs of dorsal spines and one pair

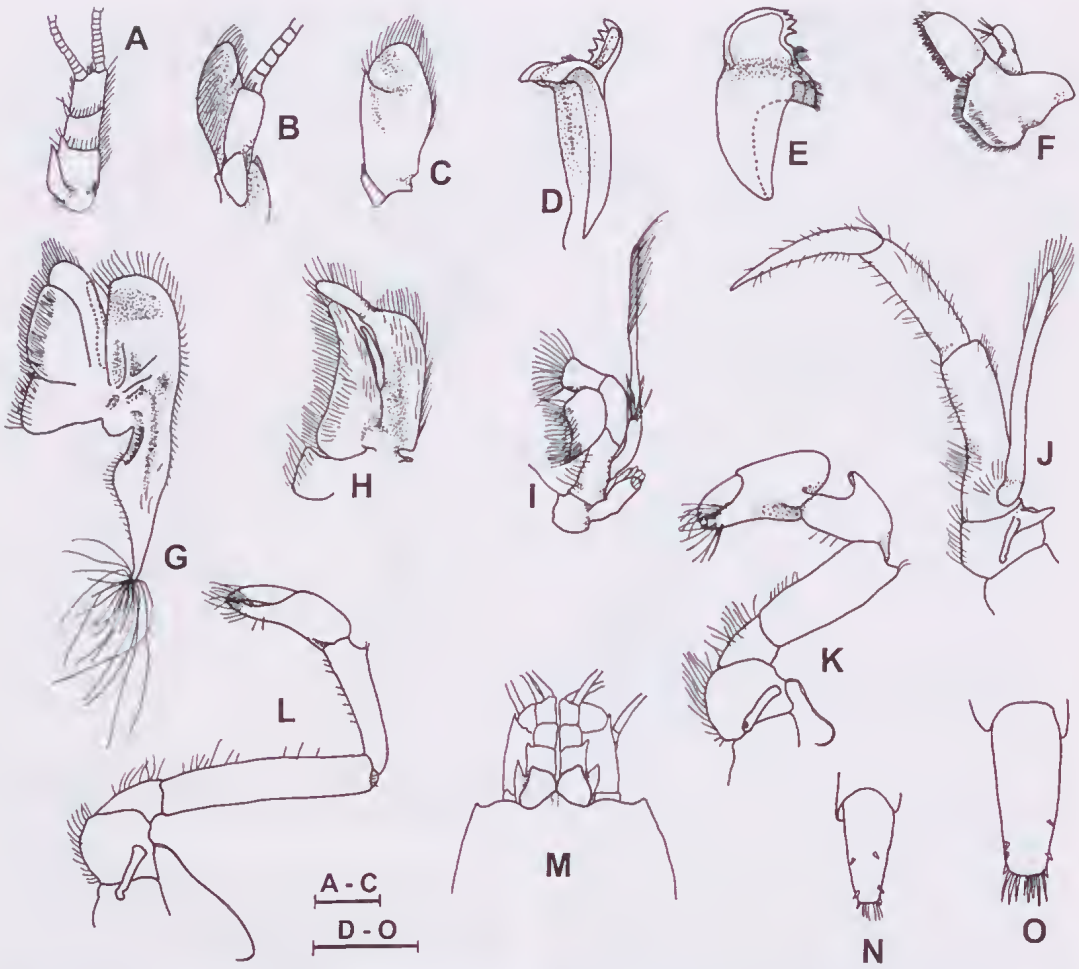

FIG. 3. *Pycnisia bunyip*, sp. nov. A-L, ♀ paratype (QMW26725): A, left antennule; B, ventral view of left antenna; C, scaphoeerite of left antenna; D, ventral view of mandible; E, dorsal view of mandible; F, left maxillule; G, left maxilla; H, first maxilliped; I, second maxilliped; J, third maxilliped; K, first pereiopod; L, second pereiopod. M-N, ♀ paratype (QMW26723): M, dorso-frontal view of carapace; N, dorsal view of telson. O, ♀ paratype (QMW26724), dorsal view of telson. Scale bars = 1mm.

of subdorsal spines (four pairs of dorsal spines and one pair of subdorsal spines in *P. raptor*).

The setobranch and multidenticulate seaphognathite setae are known to have an important gill-cleaning role in some caridean shrimps (Bauer, 1981, 1989; Suzuki & McLay, 1998). *Pycnisia bunyip* has one or two setobranchs on the coxae of the pereiopods, and 20 multidenticulate scaphognathite setae similar to other atyid species. Four Australian troglophilic shrimps, *Parisia gracilis*, *P. unguis*, *Pycneus morsitans* and *Pycnisia raptor*, also have setobranch and several long multidenticulate setae clearly belonging to the seaphognathite (Bruce, 1992; Holthuis, 1986; Williams, 1964). These species, along with *P. bunyip*, are thought to have passive gill-cleaning mechanisms as occur in other atyid species. However, *Stygiocaris lancifera* and *S. stylifera* have no long setae on the posterior portion of the seaphognathite (Holthuis, 1960). These two species are thought to have either an active gill-cleaning mechanism using a pereiopod setal brush, or a different form of passive gill-cleaning using branchiostegal setae (Bauer, 1998; Batang & Suzuki, 2000). Future study of gill-cleaning mechanisms of cavernicolous shrimps may be useful for

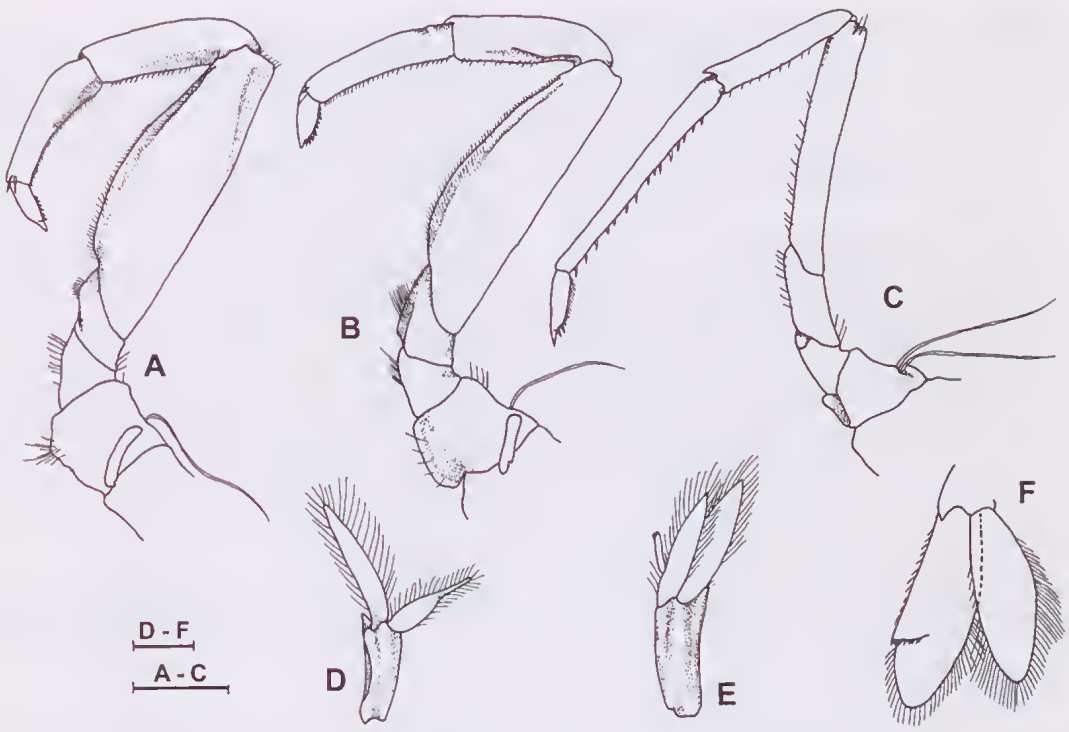

FIG. 4. *Pycnisia bunyip*, sp. nov., ♀ paratype (QMW26725): A, third pereiopod; B, fourth pereiopod; C, fifth pereiopod; D, first pleopod; E, second pleopod. Scale bars = 1mm.

understanding adaptive selection pressures and phylogenetic relationships.

DISTRIBUTION. Only known from the type locality.

ACKNOWLEDGEMENTS

We are very grateful to Stefan Williams for the collection and donation of the specimens, and the Japanese Government for a travel grant to H. Suzuki. A.J. Bruce and Xinzheng Li are thanked for their useful comments on the manuscript.

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A NOTE ON THE HABITAT REQUIREMENTS OF THE SWAMP CRAYFISH ON BRIBIE ISLAND, SOUTHEASTERN QUEENSLAND. *Memoirs of the Queensland Museum 49(1): 452, 2003:-* *Tenuibranchiurus glypticus* (Riek, 1969) is a little studied freshwater crayfish with a distribution restricted to acidic wallum (sedge-heath) swamps along the southeastern coast of Queensland. This report describes the physical conditions and habitats in which *T. gypticus* are found.

Observations were made at 38 sites on Bribie Island in southeastern Queensland from February to March of 2001. Bribie Island is a low-lying sand island with many areas dominated by wallum heath vegetation and characterised by pools of tannin-stained water. Sampling sites were swamps and small artificial dams, and pools and gutters occurring beside and across sandy vehicular tracks. Sampling was conducted with dip nets using standard sweeps and all animals captured were identified, enumerated and released at point of capture. A range of physical parameters were recorded (pH, substrate type, turbidity and presence of vegetation) in order to ascertain whether *T. glypticus* was associated with any pool characteristics.

T. glypticus was caught at 20 of the 38 sites sampled (19 of 34 temporary pools and 1 of 4 permanent pools). Most pools were tannin-stained (n = 35) and pH ranged from 2.6-5.65. *T. glypticus* were found in pools with pH ranging from 3.2-4.80, and were not found in any of the three pools with clear water. *T. glypticus* were more likely to be found in pools with a sandy substrate(62% of 29 pouls) than in pools with a thick layer of organic matter (22% of 9 pools; Fishers Exact test, p=0.058).

More pools with vegetation in the middle contained *T. glypticus* (85% of 13 pools) than pools without vegetation in the middle (36% of 25 pools; Fishers Exact test = 6.28, p=0.012). *T. glypticus* were more common in pools with the sedge *Rastio pallens* (80% of 24 pools with *R. pallens* v 44% of 14 pools without; Fishers Exact test, p=0.035). *T. glypticus* presence was positively associated with the presence of insect predators (Anisopteran odonate nymphs and/or Nepid hemipterans) (100% of 11 pools with insects v 33% of 27 pools without; Fishers Exact test = 11.4, p<0.001), and the crayfish *Cherax robustus* (76% of 17 pools with *C. robustus* v 33% of 21 pools without; Fishers Exact test = 5.39, p=0.020), but these associations were most likely due to common habitat requirements of these species. The only fish species found in samples was the Striped gudgeon (*Gobiomorphus australis*) (6 pools, 2 with *T. glypticus*).

In 7 of the 20 pools in which *T. glypticus* were found, catch rates (number/standard sweep) were compared between sweeps through sedges (24 sweeps) and sweeps over bare substrate (50 sweeps). Catch rate was significantly higher in sedges (mean $_{sedge}$ = 1.12,s.d= 0.39, n=7; mean $_{non\ sedge}$ = 0.00, s.d=0, n=7; Wilcoxon z = -2.46, p=0.014).

Of the 20 sites where *T. glypticus* was collected, all were within wallum heath areas containing tannin-stained pools. *T. glypticus* was only captured within vertical standing sedges. This may indicate that sedges provide protection from predators, or provides a food requirement. The data suggest that *T. glypticus* has specific habitat requirements within the wallum areas in which it is found. These habitat characteristics need further investigation in order to understand the ecology of this unique crustacean.

Acknowledgements

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NESTING STRATEGIES OF THE WATER MOUSE *XEROMYS MYOIDES* IN SOUTHEAST QUEENSLAND

STEVE VAN DYCK AND IAN GYNTHER

Van Dyck, S. & Gynther, I. 2003 06 30: Nesting strategies of the Water Mouse *Xeromys myoides* in southeast Queensland. *Memoirs of the Queensland Museum* 49(1): 453-479. Brisbane. ISSN 0079-8835.

Studies of *Xeromys myoides* nests on three islands of Moreton Bay and at ten coastal sites on mainland southeast Queensland have revealed a variety of nesting strategies ranging from the construction of large, free-standing, termitarium-like mounds up to 66cm high, to the excavation of inconspicuous tunnels in the supralittoral bank at the marine/terrestrial boundary. Techniques employed to locate nests and useful features for confirming the identification of *X. myoides* nesting structures are provided. Information from a total of 110 nests was compiled. Of these, 21 were free-standing structures within areas of sedgeland, chenopod shrubland, *Sporobolus virginicus* grassland or mangroves. Others were associated with small, slightly elevated 'islands' standing away from the supralittoral bank (20 nests) or with the supralittoral bank itself (20). Thirty-one examples of nests constructed in living or dead trees situated in the intertidal zone (or at its landward edge) were documented. Another eighteen nests were recorded in spoil heaps of human origin. Information about the height of nest structures and the number of holes providing access to nests is supplied. Where mound structures were present, their height was built up over time with repeated plastering of 'mortar' brought from within or below the nest and smeared from one or more entry holes to the mound top in clearly defined tracks. Well-established mounds were rarely inundated entirely. Nest location and, therefore, nest type were interpreted as resultant compromises between the ability to withstand spring tides versus proximity to the most highly productive resources of the mangrove zone. ❐ *Xeromys, False Water-rat, rodents, survey, southeast Queensland.*

Steve Van Dyck, Queensland Museum, PO Box 3300, South Brisbane 4101, (stevevd@qm.qld.gov.au); Ian Gynther, Conservation Service, Queensland Parks and Wildlife Service, Southern Region, PO Box 64, Bellbowrie 4070, Australia; *12 April 2002.*

Magnusson et al. (1976) described an extraordinary, 60cm-high mud structure resembling a termite mound, built at ground level against the trunk of a living *Bruguiera parviflora* in a mangrove forest on Melville Island, Northern Territory. From this structure they extracted an adult female *Xeromys myoides* and two young, thereby documenting the first record of a nest for this poorly known species. In 1991, a number of sedge-covered peat mounds attributed to *X. myoides* were found on North Stradbroke Island, southeast Queensland (Van Dyck, 1992; Van Dyck & Durbidge, 1992). None of these occurred in mangroves but rather in immediately adjacent areas of sedgeland or on the more landward supralittoral bank (Van Dyck, 1997). The present investigation of *X. myoides* nesting elsewhere on North Stradbroke Island, as well as on South Stradbroke and Bribie Islands and at ten mainland sites in coastal southeast Queensland, has revealed a variety of nesting strategies for the species. These ranged from the construction of large free-standing termitarium-like mounds to the exploitation of hollow trunks within (or at the landward edge of) the tidal zone and the excavation of inconspicuous tunnels in the supralittoral bank at the marine/terrestrial boundary. The information presented here has been compiled from a total of 110 nests documented by us since 1991. It presents a broad range of nesting strategies hitherto unrecorded for this threatened species.

METHODS

Nesting structures were documented as part of an ongoing survey of *X. myoides* in southeastern Queensland and northeastern New South Wales. Nests were recorded at sites examined between the Great Sandy Strait, Queensland (25°47'S, 152°58'E) and the Richmond River area of New South Wales (28°54'S, 153°31'E), 345km to the south (Table 1, Fig. 1). Nests were generally located by searching in the intertidal zone between the supralittoral bank and the outer (frequently seaward) edge of the mangroves. However, some nests involving simple holes excavated in the supralittoral bank or in spoil heaps were revealed only during the radio-tracking of individuals that

TABLE 1. *Xeromys myoides* nest localities, abundance and nest reference numbers in Queensland, and localities searched (unsuccessfully) in New South Wales (ordered by increasing latitude).

	Locality	Lat. (S)	Long. (E)	Total Nests	Ref. Nos.
Queensland	Kauri Creek Conservation Park	25°47'	152°58'	6	1-6
	Noosa North Shore	26°23'	153°04'	6	7-12
	Maroochy River	26°38'	153°04'	1	13
	Pumicestone Passage	26°59'	153°04'	8	14-21
	Gallagher Point, Bribie I.	27°00'	153°06'	5	22-26
	Bullock Creek Conservation Park	27°00'	153°04'	3	27-29
	Donnybrook	27°01'	153°03'	17	30-46
	White Patch, Bribie I.	27°01'	153°07'	1	47
	Amity, N. Stradbroke I.	27°25'	153°26'	4	48-51
	Rainbow Channel, N. Stradbroke I.	27°27'	153°25'	10	52-61
	Canalpin Creek, N. Stradbroke I.	27°36'	153°24'	1	62
	Stockyard, N. Stradbroke I.	27°43'	153°24'	1	63
	Steiglitz	27°45'	153°20'	4	64-67
	Jacobs Well	27°46'	153°21'	1	68
	Pimpama River	27°48'	153°20'	1	69
	Coomera River	27°50'	153°22'	22	70-91
	South Stradbroke I.	27°51'	153°25'	19	92-110
New South Wales	Cobaki Broadwater (3 sites)	28°11'	153°30'		
	Terranora Creek A (2 sites)	28°11'	153°32'	-	-
	Ukerebagh Island	28°11'	153°33'	-	-
	Terranora Creek B (3 sites)	28°12'	153°31'	-	-
	Ukerebagh Mainland	28°12'	153°33'	-	-
	Fingal	28°12'	153°34'	-	-
	Terranora Broadwater (3 sites)	28°13'	153°30'	-	-
	Banora Point (4 sites)	28°13'	153°33'	-	-
	Chinderah Bay (3 sites)	28°14'	153°33'	-	-
	Cudgen Creek, Kingscliff	28°17'	153°34'	-	-
	Hastings Point (2 sites)	28°22'	153°34'	-	-
	Brunswick River	28°32'	153°32'	-	-
	Marshalls Creek, Brunswick Heads	28°32'	153°33'	-	-
	Simpsons Creek, Brunswick Heads	28°33'	153°33'	-	-
	Belongil Creek, Byron Bay	28°38'	153°35'	-	-
	North Creek, Ballina	28°51'	153°34'	-	-
	South Ballina	28°53'	153°33'	-	-
	Hermans Wharf, Richmond River	28°54'	153°31'	-	-

used these tunnels (Van Dyck, 1997). A more detailed description of search techniques is provided below.

Up to four different vegetation communities occurred in the intertidal search area and, wherever possible, the location of each *X. myoides* nest was recorded with respect to these communities. Based on the definitions of Clifford & Specht (1979), the communities encountered were:

1) sedgeland — an often well-defined zone of rushes and sedges growing to about 1m and typically including *Juncus kraussii* and *Baumea juncea*. The Mangrove Fern *Acrostichum speciosum* occasionally grows here.

2) chenopod shrubland — a less frequently encountered low, open shrubland of succulents with a dwarf shrub habit growing on soils that dry out and crack between inundations. Plant species typically include *Enchylaena tomentosa*,

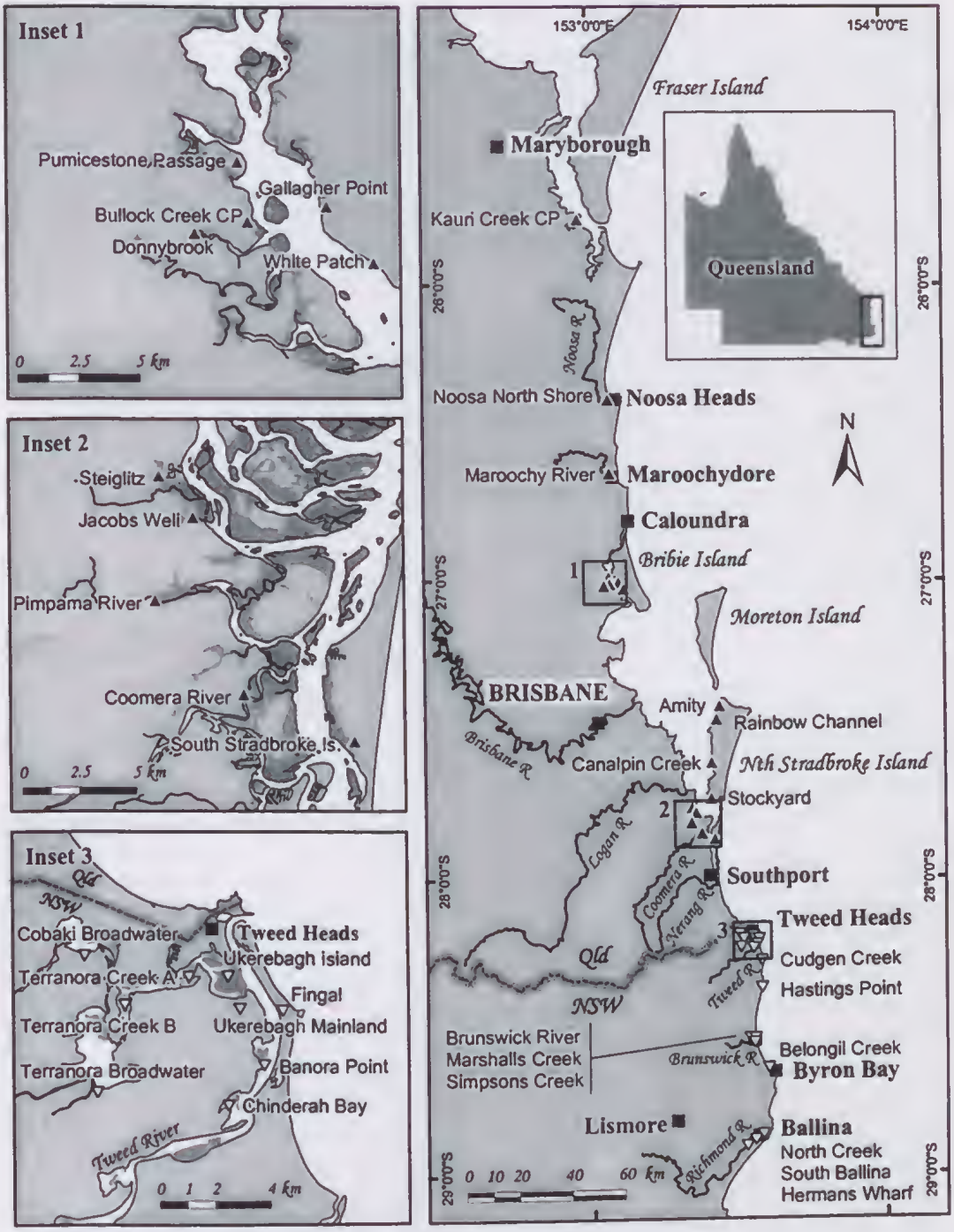

FIG. 1. Distribution of *Xeromys myoides* nesting localities in Queensland (▲), and localities searched (unsuccessfully) in New South Wales (▽).

Sarcocornia quinqueflora, *Suaeda arbusculoides* and *Suaeda australis*.

3) *Sporobolus* grassland — a salt meadow of Marine Couch *Sporobolus virginicus* closed grassland, usually found closest to the extreme high water spring tide mark and associated with freshwater drainage.

4) mangroves — a community of varying structural type and complexity, but usually comprising one or more of *Avicennia marina* var. *australasica*, *Rhizophora stylosa*, *Bruguiera gymnorhiza*, *Aegiceras corniculatum* and, less commonly, *Ceriops tagal*. Dowling (1986) and Van Dyck (1997) provide additional details of the many mangrove communities occurring in Moreton Bay.

In situations where more than one of these intertidal communities was present at a site, distinct zonation was often apparent. This made assignment of a *X. myoides* nest to a particular community easy. At other times the boundaries between the various communities were blurred or the communities interdigitated such that clear zonation of the different vegetation types was not obvious. In these cases, a nest was associated with the dominant vegetation community in its proximity.

Each nest was assigned to one of five nest categories (below) and its location determined with a GPS navigator. The vegetation cover on the nest, nature of the mound material, number and position of entrance/exit holes and height and circumference of the mound were recorded. The degree of moating by high tides was also assessed. Finally, the nest's position in the intertidal zone was put into perspective in relation to the vegetation communities occurring along a linear transect that started at the terrestrial boundary and passed through the nest to terminate at the closest deep channel or large body of water out into or beyond the associated mangroves.

SEARCH TECHNIQUES. Techniques employed to locate nests of *X. myoides* are described. As previously stated, manual searching was conducted across the entire intertidal zone. Particular attention was paid to areas of higher ground abutting or lying within the various intertidal vegetation communities, i.e. places that offer some elevation and, therefore, refuge against the high tide. Where a defined supralittoral bank existed, this was searched thoroughly for mud moundings or other signs of *X. myoides*. Other areas of high ground that were potentially suitable for nesting were detected by the different nature of the vegetation they supported. Small 'islands' at the same elevation as the supralittoral bank often existed in the landward sections of the intertidal zone. These supported terrestrial trees or shrubs such as *Melaleuca quinquenervia*, *Casuarina glauca* and *Baccharis halimifolia*, and were surrounded by *Sporobolus* grassland, sedgeland or chenopod shrubland. Locations seaward of the supralittoral bank where such trees occurred were investigated closely.

Local topography at each site was also carefully considered. At some localities, for example, narrow tongues or even large islands of coastal woodland lay partly or entirely encircled by mangroves or other intertidal vegetation types, offering many nesting opportunities for *X. myoides*. These terrestrial isolates were located by scanning across the canopy of the mangrove community to detect the obvious crowns of *Casuarina glauca* or other terrestrial tree species. Routine study of colour aerial photography (1:12,000 scale or better) of each survey site ensured that the discovery of such areas of high ground was not left to chance.

In addition to searching for these obvious topographical features offering nesting potential, subtler evidence was sought of raised areas within the intertidal zone created directly by *X. myoides* activity or by human disturbance. Amidst *Sporobolus* grassland or chenopod shrubland, mounded nest structures constructed by Water Mice or mounds of artificial origin (e.g. human spoil piles) were usually obvious. Within taller vegetation, such as sedgeland or stands of *Acrosticlum speciosum*, this was not always the case. Nevertheless, because the tops of such mounds are seldom, if ever, inundated by high tides, they often bore a lush growth of *Sporobolus virginicus*. Consequently, stands of *Juncus kraussii*, *Baumea juncea* or *A. speciosum* were scanned for these tell-tale clumps of *S. virginicus*. Where these clues to possible nest structures were lacking, extensive areas of *J. kraussii*, *B. juncea* or *A. speciosum* were systematically traversed using parallel transects to locate otherwise concealed nest mounds. Minor contour changes in the overall height of the sedge or fern stands were closely investigated to determine whether these were due to raised substrate or a nest mound. Within the intertidal zone, bund walls, piles of spoil material from earthworks and bulldozed trees with associated root clods were examined carefully for evidence of colonisation by *X. myoides*.

Reward for search effort was greatly increased if surveying for nests in dense intertidal vegetation or lush ground cover on the supralittoral bank was undertaken after recent fires had swept through an area. At such times, signs of *X. myoides* activity including access holes, mud tracks and daubing (below) were more readily observable. In some cases, nest structures were revealed that had been overlooked during previous surveys.

Nest searching within the mangrove zone was conducted less methodically due to the often extensive area needing to be covered. Dead trees and stumps and hollow, living mangroves encountered while conducting such searches or while setting Elliott trap transects were inspected for evidence of *X. myoides* nesting activity. Signs of occupation sought included mounded mud structures located at ground level within hollow trunks, mud packing against the bases of trunks or any mud or peat material in tree trunks and limbs above ground level.

RESULTS

DISTRIBUTION OF NESTING RECORDS. A total of 110 nests belonging to *X. myoides* was discovered at 17 of 28 localities searched along the coastline of southeastern Queensland (Fig. 1, Table 1). These searched localities were scattered from Kauri Creek, Great Sandy Strait (25°47'S, 152°58'E), south to Currumbin Creek on the Gold Coast (28°08'S, 153°28'E). No evidence of *X. myoides* nesting activity was found at four mainland sites south of the Coomera River in Queensland or at any of the 31 sites (from 18 localities) surveyed in New South Wales (Fig. 1, Table 1).

NESTING STRATEGIES. Nesting structures of *X. myoides* encountered at sites surveyed in southeast Queensland were categorised into one of the following five broad types: 1) free-standing nests, 2) island nests, 3) supralittoral bank nests, 4) tree trunk nests, and 5) spoil heap nests. Photographs (Figs 2-15) and relevant details of nests from each class should aid recognition of these structures by field workers. Figure 16 illustrates the diversity of *X. myoides* nest types and locations within the different intertidal vegetation communities. Although these five categories offer a useful scheme for documenting the range of *X. myoides* nesting structures, the classification proved to be somewhat arbitrary with, in some situations, the divisions between certain nest types being unclear. For example, free-standing mounds built against tree bases or against clods of soil between the roots of upturned trees could be classified as tree trunk nests or spoil heap nests, respectively (below). Such difficulties, however, were the exception rather than the rule.

1. Free-standing Nests. Free-standing nests were solitary, termitarium-like mounds. They were not associated with either the supralittoral bank, areas of substrate elevated above their surroundings ('islands' and spoil piles) or (except in rare instances) hollow tree trunks or stumps. They occurred in: (i) the mangrove zone (Fig. 2); (ii) sedgeland (Fig. 3); (iii) chenopod shrubland; or (iv) *Sporobolus* grassland (Fig. 4).

The locations and physical features of free-standing mounds documented during the study appear in Table 2. Free-standing nests were always more conspicuous than other nest types, often being large constructions up to 66cm high (mean = 42cm, SD = 12cm, n = 20; minimum height of occupied nests 25cm). All experienced 360° moating at high tide. This nest type was recorded mainly from areas of sedgeland and *Sporobolus* grassland (18 out of 21 cases), with only one example from chenopod shrubland and two noted inside the mangrove zone. One of these mangrove mounds (Stockyard #63) had been abandoned at some point up to 3.5 years after it was first discovered (below). The other (Pumicestone Passage #17) was situated in an area of minimal tidal influence. Occupied nests were thickly covered with Marine Couch (14 out of 20 cases), the sedges *Juncus kraussii* or *Baumea juncea* (5 out of 20 nests) or a combination of sedge and couch (one case). A smaller additional component of cover was contributed in some instances by *Suaeda arbusculoides*, *S. australis*, *Vitex bicolor* or *Acrostichum speciosum*. When first recorded, nest #63 at Stockyard, North Stradbroke Island, was partially covered with *S. australis*. However, when revisited 3.5 years later, this vegetation had all died and the nest was abandoned.

Free-standing nests occurred either in areas receiving infrequent flooding by tides or areas that experienced more regular inundation but offered a high degree of protection from erosional action (wind-induced waves and/or tidal currents). This protection was due to the buffering effect of an adjacent broad mangrove zone or because the areas were situated along calm waterways. The sheltered Marine Couch and *Sarcocornia quinqueflora* flats of the western shores of Pumicestone Passage,

FIG. 2. A free-standing nest in the mangrove zone (nest #17, Pumicestone Passage, November 1996). Photo Ian Gynther.

intersected by extensive natural ponds and shallow drainage ditches, and located far from the deep water of the Passage itself, provided the most numerous examples of this nest type. In such areas, given the limited exchange of surface waters, mangrove community composition was limited to one species (*Avicennia marina*) that grew no taller than 5m.

Nests on the Noosa River (#s 9,10) and Coomera River (#s 76,77,87) were subject to more extensive tidal inundation than those at Pumicestone Passage but occurred in similarly sheltered areas amid broad expanses of *Sporobolus* grassland or sedgeland and, in these cases, adjacent to calm river channels. The free-standing nests at Kauri Creek Conservation Park (#s 2,6), Rainbow Channel (#57) and South Stradbroke Island (#s 95,102,103) were all recorded closer to potentially destructive tidal influences, but occurred on the landward side of 153-400m-wide mangrove stands that included *Rhizophora stylosa* as a significant component. The dense tangles of prop roots typical of this mangrove species would offer an effective barrier against strong tidal currents, storm surge and wind-induced waves. As would be expected in such regularly inundated sites, these nests were densely consolidated by species with a greater salt water tolerance, namely sedges and Mangrove Fern, and were closer to more diverse mangrove communities. The remaining nest, at Bullock Creek Conservation Park (#29), represented an intermediate situation. Although the surrounding sedgeland here was not extensive, a 290m-broad mangrove zone stood between it and the relatively sheltered waters of Pumicestone Passage.

Free-standing nests were often constructed at great distances from both the terrestrial woodland community and deep water, further emphasizing the typically sheltered nature of the locations at which these nests occurred. For example, nests #17 (Pumicestone Passage) and #63 (Stockyard) were 131m and 200m, respectively, from the marine/terrestrial boundary, and many nests (#s 2,6,10,29,63, 95,102,103) were at least 250m from the nearest body of deep salt water. Those at Kauri Creek Conservation Park (#s 2,6) were 427m and 520m from the closest channel. With one exception (Rainbow Channel #57), all Type 1 nests were located adjacent to sections of the shoreline that lacked a distinct supralittoral bank.

FIG. 3. A free-standing nest in sedgeland (nest #10, Noosa North Shore, April 1997). Photo Ian Gynther.

FIG. 4. A free-standing nest in *Sporobolus* grassland (nest #18, Pumieestone Passage, November 1996). Photo Steve Van Dyek.

The greatest number of aeeess holes (25) of any nest type was reeorded from a free-standing nest mound (Pumieestone Passage #14).

2. Island Nests. 'Island' nests were eonstrueted away from the supralittoral bank in areas of substrate that were slightly higher than their surroundings and generally above the level of spring tides. They were often eonsolidated by the roots of trees such as *Melaleuca quinquenervia* and *Casuarina glauca*, or thiekly eovered with sedges and/or *Sporobolus virginicus*. These 'islands' may represent vestiges of the supralittoral bank, eroded by the eombined effeets of spring tides, wind-indueed waves and storm surge. Most 'islands' were, therefore, eloser to the supralittoral bank than to the mangroves. Island nests oeeurred in: (i) the mangrove zone (Fig. 5); (ii) sedgeland (uneommonly ineluding *Acrostichum speciosum*) (Fig. 6); (iii) ehenopod shrubland; or (iv) *Sporobolus* grassland. They sometimes eomprised simple holes with no other signs of working by *X. myoides*, but more often were eomplex eonstruetions with additional mounding.

Loeations and physieal features of island nests are shown in Table 3. Nests eonstrueted on islands were seeond to free-standing nests in their ease of detection. The maximum reeorded size of such an island was approximately 15m^2 (Donnybrook #44). The mean height of island nests above the surrounding littoral substrate was 51em (range = 30-75em, SD = 13em, n = 20). All islands were fully moated at high tide and most (19 out of 20 examples) were eonsolidated by the roots of a few salt-tolerant shrubs and trees such as *Casuarina glauca*, *Baccharis halimifolia* and *Melaleuca quinquenervia* or the mangroves *Avicennia marina* and *Aegiceras corniculatum*. The only island nest not associated with shrubs or trees (Donnybrook #38) was situated in the middle of an extensive area of low, *Sporobolus virginicus*-eovered plateaux, intersected by a labyrinth of natural, shallow channels and poorly draining pools.

All islands were thiekly eovered with ground layer vegetation: Marine Couch (11 out of 20 eases, ineluding nest #38), sedges (five out of 20), couch and sedges (two out of 20) or sedges and Mangrove Fern (two out of 20). Marine Couch eover generally eharaeterised more sheltered loeations (e.g. Donnybrook; seetions of Gallagher

FIG. 5. An island nest with obvious mounding in the mangrove zone (nest #37, Donnybrook, November 1996). Photo Ian Gynther.

FIG. 6. An island nest in sedgeland (nest #72, Coomera River, November 2001). Photo Ian Gynther.

Point on Bribie Island) whereas sedges or the combination of sedges and fern, i.e. species tolerant of a higher frequency of inundation by salt water, occurred in areas potentially more prone to erosion by spring tides, wind-induced waves and storm surge (e.g. certain sections of Kauri Creek Conservation Park, Amity, Rainbow Channel and South Stradbroke Island). Nest #27 at Bullock Creek Conservation Park, situated in an area exposed to only moderate erosional forces, consisted of a *Sporobolus*-covered island (with a single *Casuarina glauca*) within dense sedgeland. Nest #74 at Coomera, another area of intermediate shelter, was covered by a combination of Marine Couch and sedges (with an individual *C. glauca*). Couch and sedges also covered one Donnybrook nest (#44), although Marine Couch dominated, as was consistent with the nest's sheltered location.

Island nests were usually located closer to the supralittoral bank or, where this was poorly defined, the marine/terrestrial boundary (median distance = 12m) than were free-standing nests (median distance = 41m) or tree trunk nests (median distance = 75m), most probably because the island landforms bearing *X. myoides* nests originated through erosional processes operating on the supralittoral bank. One exception, nest #37 at Donnybrook (Fig. 5), was located on an island in an isolated, raised area of sparse *Sporobolus* a distance of 195m into the mangroves from the landward edge of the intertidal zone. Although couch-covered, undermining of the structure by spring tides was apparent at around 20cm above the substrate level.

The tops of all but one island nest (Amity #50) were plastered by *X. myoides* with successive layers of mud or peat daubing which, over time, had produced mounds, effectively increasing their height against spring tides.

The greatest number of access holes recorded from island nests was seven (nest #s 37,48,110).

3. Supralittoral Bank Nests. Supralittoral bank nests were built into or on the earth bank formed by erosional action at the marine (mangrove, sedgeland, chenopod, *Sporobolus*)/terrestrial (swamp, wallum, coastal woodland) ecotone by the highest of tides (Fig. 7). Such nests were either: (i) simple holes excavated into the vertical bank; or (ii) more elaborate constructions with additional mounding (Fig. 8).

Twenty supralittoral bank nests were recorded. The physical features of these are provided in Table 4. Type 3 nests were more difficult to locate than other types because banks were naturally uneven in profile and thickly covered with Marine Couch, sedges or shrubs, and because mounding associated with such nests was either nonexistent or occurred in various stages of development. In the former case, inconspicuous holes were built among peat and roots in the bank. In the absence of peat or mud plastering above these nests, the three recorded examples (Rainbow Channel #s 54,55; Canalpin Creek #62) were discovered only during the course of radio-tracking studies.

In one case, at Donnybrook, a recent fire that had burned to the supralittoral bank and into the fringes of the *Sporobolus* grassland exposed three nests that had not been detected during an earlier survey (Fig. 17).

Supralittoral bank nests, being located at the marine/terrestrial boundary, were not as prone to inundation and so experienced less moating than other nest types. The usual extent of moating of nests in the supralittoral bank was 180°, although the maximum recorded (270°) occurred in situations where the bank formed small promontories jutting out into the adjacent

TABLE 2. Free-standing nest mounds (Type 1) of *Xeromys myoides* from southeast Queensland. * The term 'sedge' refers to the combination of *Juncus kraussii* and *Baumea juncea*. Abbreviations: CP, Conservation Park; H, height of nest mound; Circ., circumference of nest mound at base.

Ref. No.	Locality	Lat (S)	Long (E)	Veg. Zone	H (cm)	Circ. (m)	Material	Holes	Veg. Cover
2	Kauri Ck CP	25°46'57"	152°58'28"	sedgeland	60	4.5	peat/mud/ sand	12; 10 @ 0cm, 10cm, 20cm	*S. virginicus*
6	Kauri Ck CP	25°47'14"	152°57'44"	sedgeland	35	1.5	black soil	2; 2 @ 0cm	*J. kraussii*
9	Noosa North Shore	26°23'31"	153°03'58"	sedgeland	31	2.5	grey sand	6; 2 @ 0cm, 2 @ 2cm, 2 @ 3cm	*J. kraussii*, *S. virginicus*
10	Noosa North Shore	26°23'35"	153°03'47"	sedgeland	36	3.0	sand	3; 2 @ 0cm, 5cm	*S. virginicus*
14	Pumicestone Passage	26°59'10"	153°03'46"	*Sporobolus*	60	6.0	dark loam	25; 6cm, 2 @ 8cm, 9cm, 10cm, 2 @ 13cm, 14cm, 15cm, 2 @ 16cm, 3 @ 17cm, 2 @ 18cm, 19cm, 2 @ 20cm, 2 @ 21cm, 2 @ 22cm, 31cm, 32cm	*S. virginicus*
15	Pumicestone Passage	26°59'18"	153°03'51"	chenopod	35	4.7	peat/mud	9; 0cm, 3cm, 5cm, 6cm, 8cm, 3 @ 10cm, 11cm	*S. virginicus*
16	Pumicestone Passage	26°59'21"	153°03'59"	*Sporobolus*	40	3.8	peat/mud	13; 6 @ 0cm, 8cm, 10cm, 14cm, 15cm, 16cm, 18cm, 25cm	*S. virginicus*, *S. arbusculoides*
17	Pumicestone Passage	26°59'21"	153°04'03"	mangrove	60	5.1	peat/mud	23; 12 @ 0cm, 3 @ 12cm, 3 @ 15cm, 3 @ 18cm, 22cm, 24cm	*S. virginicus*, *S. australis*
18	Pumicestone Passage	26°59'21"	153°04'09"	*Sporobolus*	48	4.7	mud/sand/ loam	10; 0cm, 3cm, 5cm, 8cm, 10cm, 12cm, 14cm, 20cm, 34cm, 48cm	*S. virginicus*
19	Pumicestone Passage	26°59'26"	153°04'01"	*Sporobolus*	48	4.1	mud	8; 3cm, 8cm, 11cm, 12cm, 2 @ 13cm, 24cm, 46cm	*S. virginicus*
20	Pumicestone Passage	26°59'26"	153°04'08"	*Sporobolus*	27	2.4	peat/loam	8; 2 @ 0cm, 6cm, 2 @ 8cm, 10cm, 2 @ 15cm	*S. virginicus*
21	Pumicestone Passage	26°59'31"	153°03'42"	*Sporobolus*	40	4.5	mud/loam	19; 13 @ 0cm, 5cm, 3 @ 8cm, 10cm, 11cm	*S. virginicus*
29	Bullock Ck CP	27°00'47"	153°04'11"	sedgeland	48	3.2	clay/mud/ sand	17; 13 @ 0cm, 10cm, 13cm, 14cm, 15cm	*S. virginicus*
57	Rainbow Channel	27°27'35"	153°25'38"	sedgeland	66	4.7	peat/mud/ sand	6; 3 @ 0cm, 20cm, 40cm, 45cm	sedge* (1.6m), *Vitex bicolor*
63	Stockyard	27°43'29"	153°24'26"	mangrove	23	3.7	mud	none (abandoned)	dead *S. australis*
76	Coomera R	27°50'27"	153°22'41"	*Sporobolus*	25	3.4	mud	1; 20cm	*S. virginicus*
77	Coomera R	27°50'30"	153°22'45"	*Sporobolus*	25	6.0	mud	7; 5 @ 5cm, 2 @ 20cm	*S. virginicus*
87	Coomera R	27°50'52"	153°22'22"	*Sporobolus*	36	3.6	mud	4; 10cm, 2 @ 25cm, 31cm	*S. virginicus*
95	S Stradbroke	27°51'34"	153°25'06"	sedgeland	37	4.2	black peat	5; 4 @ 0cm, 33cm	*J. kraussii* (1.3m), *A. speciosum*
102	S Stradbroke	27°51'39"	153°25'08"	sedgeland	40	4.4	peat/grey sand	6; 3 @ 0cm, 24cm, 35cm, 40cm	*J. kraussii*, *A. speciosum*
103	S Stradbroke	27°51'39"	153°25'10"	sedgeland	50	4.8	peat/grey sand	13; 5 @ 0cm, 7 @ 20-25cm, 40cm	*J. kraussii*, *A. speciosum*

intertidal area (Donnybrook #s 31,32). An intermediate degree of moating at high tide was noted for two nests, #s 56 and 57, at Rainbow Channel (210° and 200° moating, respectively). The mean height of supralittoral bank nests was 55cm (range = 35-80cm, SD = 15cm, n = 17). Nests were documented up to 32m from the mangrove community and up to 11 access holes were recorded. Ten of the nests were incorporated among the roots of living or dead trees or shrubs.

4. Tree Trunk Nests. Tree trunk nests relied on a hollow tree or stump to provide the supportive

TABLE 3. Island nests (Type 2) of *Xeromys myoides* from southeast Queensland. Abbreviations: CP, Conservation Park; H, height of the island plus any additional mounding (often it was impossible to dissociate the two); Circ., circumference of the island. * The term 'sedge' refers to the combination of *Juncus kraussii* and *Baumea juncea*.

Ref. No.	Loeality	Lat (S)	Long (E)	Veg. Zone	H (em)	Circ. (m)	Material	Holes	Veg. Cover
5	Kauri Ck CP	25°47'10"	152°58'24"	ehenopod	45	5.1	mud/sand	4; 3 @ 0em, 10cm	*J. kraussii*, *C. glauca*
22	Gallagher Pt	27°00'18"	153°06'03"	sedgeland/ *Sporabolus*	45	3.9	peat/loam	4; 0em, 2 @ 8em, 11em	dead *C. glauca* (1.2m), *S. virginicus*
23	Gallagher Pt	27°00'18"	153°06'03"	sedgeland/ *Sporobolus*	32	3.1	peat/loam	4; 3 @ 0cm, 12cm	*S. virginicus*, dead *C. glauca* (0.7m), *M. quinquenervia*
27	Bulloek Ck CP	27°00'43"	153°04'11"	sedgeland	55	10.2	mud/grey sand	3; 3em, 2 @ 10em	*S. virginicus*, *C. glauca* (7.0m & 1.2m)
34	Donnybrook	27°00'59"	153°02'57"	*Sporabolus*	45	6.2	elay-mud/ loam	6; 2 @ 10em, 2 @ 13em, 22em, 45em	*S. virginicus*, *A. corniculatum* (1m)
37	Donnybrook	27°01'08"	153°03'09"	mangrove	75	5.6	peat/mud	7; 3 @ 20cm, 23em, 2 @ 30cm, 45em	*S. virginicus*, *C. glauca* (4m)
38	Donnybrook	27°01'09"	153°03'03"	*Sparabalus*	74	9	elay/ humus/sand	3; 29cm, 39em, 72em	*S. virginicus*
42	Donnybrook	27°01'16"	153°03'00"	*Sparabolus*	58	12	elay/loam	4; 2 @ 0cm, 3cm, 37em	*S. virginicus*, *B. halimifalia*
43	Donnybrook	27°01'17"	153°03'08"	sedgeland/ *Sparobalus*	58	12	elay/loam	6; 8cm, 9cm, 10em, 20cm, 29cm, 31em	*S. virginicus*, *C. glauca* (8m)
44	Donnybrook	27°01'21"	153°03'13"	chenopod	59	13.7	clay/loam	5; 0cm, 8em, 2 @ 10cm, 21em	*S. virginicus*, sedge*, *A. marina* (1.6m)
45	Donnybrook	27°01'22"	153°03'12"	ehenopod	60	7	elay/loam	2; 27em, 42em	*S. virginicus*, *M. quinquenervia* (4m)
48	Amity	27°24'41"	153°26'23"	sedgeland	45	2.7	grey-blaek peat/sand	7; 7 @ 0em	*S. virginicus*, *M. quinquenervia* (4m)
49	Amity	27°25'25"	153°26'14"	sedgeland	60	4.1	grey peat/sand	3; 2 @ 0cm, 20em	*B. juncea*, *M. quinquenervia* (4m)
50	Amity	27°25'26"	153°26'15"	sedgeland	40	?	nil	2; 2 @ 25em	sedge* (1m), *C. glauca*, *M. quinquenervia*
51	Amity	27°25'31"	153°26'13"	sedgeland	60	3.1	grey peat/sand	5; 2 @ 0em, 2em, 4em, 48cm	sedge*, *M. quinquenervia* (5m)
60	Rainbow Channel	27°27'52"	153°25'39"	sedgeland	60	2.4	peat/mud	5; 3 @ 0em, 2 @ 60em	sedge* (1.6m), *Phragmites australis*, *M. quinquenervia* (4m), *C. glauca* (6m)
72	Coomera R	27°50'23"	153°22'25"	sedgeland	40	9.8	blaek sandy peat	5; 3 @ 0em, 12em, 35cm	*S. virginicus*, *C. glauca* (9m)
74	Coomera R	27°50'24"	153°22'24"	sedgeland	30	6.4	blaek sandy peat	2; 0cm, 30cm	*S. virginicus*, *J. kraussii*, *C. glauca* (4m)
106	S Stradbroke	27°51'41"	153°25'09"	sedgeland	38	5.1	grey sand	6; 5 @ 0em, 15 cm	*J. kraussii* (1.3m), *A. speciasum* (1.2m), *M. quinquenervia* (4m)
110	S Stradbroke	27°51'44"	153°25'07"	sedgeland	45	8.8	peat/mud/ grey sand	7; 6 @ 0cm, 17cm	*J. kraussii* (1.3m), *A. speciosum* (1.3m), *M. quinquenervia* (5m)

frame for the mud structure built within. These mostly involved dead stags of *Eucalyptus tereticornis* (Fig. 9) or living or dead *Avicennia marina* situated within the mangrove zone (Figs 10-13). Additional examples of tree trunk nests involved living or dead *Casuarina glauca*, *Melaleuca quinquenervia* or *Excoecaria agallocha* growing at or near the marine/ terrestrial boundary.

In spite of the number of tree trunk nests recorded in or adjacent to the mangrove

FIG. 7. A supralittoral bank where tunnels made by *Xeromys myoides* are either hidden among roots or are indistinguishable from crab holes (nest #62, Canalpin Creek, North Stradbroke Island, September 1997). Photo Steve Van Dyck.

community (31), this nesting strategy was not documented widely throughout the survey area (Table 5). Numerous examples (14) were recorded from a limited area (approximately 60m × 530m) on South Stradbroke Island inside the hollowed bases of large, decayed *Eucalyptus tereticornis* stumps, now completely surrounded by a mangrove open woodland. Although an almost unlimited number of hollow-trunked mangroves is available, only ten records (Noosa North Shore #12; Donnybrook #36; Coomera River #s70,71,73, 75,78-81) were made of nests inside the trunks of living mangroves (*Avicennia marina*). Two other records were of nests inside the trunks of dead mangroves. In one case (Noosa North Shore #11), the tree involved was the rotting stump of a Milky Mangrove *Excoecaria agallocha*. In the other (Donnybrook #30), a nest was discovered in the small, leaf-lined (leaves of *Aegiceras corniculatum*) trunk of a dead mangrove, possibly *Avicennia marina*. The remaining five tree trunk nests were located inside dead or hollow-trunked but living *Melaleuca quinquenervia* (#s 1,3) or *Casuarina glauca* (#s 4,28,52) growing at the marine/terrestrial boundary or within the uppermost zone of tidal influence.

Tree trunk nests assumed a variety of forms. In most cases cavities within living or dead trees were either packed with mud or contained a mounded mud structure visible from the outside (Figs 9,10). An exception was discovered within a living *Avicennia marina* at Coomera River (nest #75). Here, the basal hollow was not entirely mud-filled but instead contained a 60cm-high, ramped mud structure built against the tree's sloping, interior wall.

Other tree nests were located within relatively small trunks that lacked large holes and so precluded the structure of the nest being observed from the outside. Consequently, it was impossible to determine whether or not the internal cavity was mud-filled. In some cases, it was not even obvious that such trunks were hollow. Even so, *X. myoides* was clearly occupying these trees because of additional mud working including mounds with at least one access hole built against the tree's base (Fig. 11), plastering of the tree's exterior surface, footprints creating tracks along

FIG. 8. A supralittoral bank nest with additional mounding (nest #24, Gallagher Point, Bribie Island, March 1999). Photo Ian Gynther.

FIG. 9. A tree nest at the base of a *Eucalyptus tereticornis* stag (nest #105, South Stradbroke Island, June 1995). Photo Ian Gynther.

the uppermost surface of sloping trunks, especially near ground level, and plugging of knot holes or the ends of broken trunks or branches (Fig. 12). In one example (Coomera River #80), the plugging of a gap in the upper surface of a dead, horizontal trunk of a living *A. marina* apparently led to the construction of a small mound of mud (10cm high) atop the broken-off trunk at a height of 86cm above ground (Fig. 13). When examined on a subsequent visit, this mound had been destroyed and a nesting chamber of leaves inside the trunk's cavity was visible. Change over time in the extent of mud working associated with tree trunk nests was not uncommon and, in certain cases involving smaller diameter mangrove trees in particular (e.g. Coomera River nest #s 70,73,78), nests were not active on later visits or could not be relocated at all as no signs of former occupation by *X. myoides* were detectable.

A final variation in tree trunk nests was seen in situations involving the broken and decaying stumps of *Casuarina glauca* or *Melaleuca quinquenervia* near the edge of the sedge zone (Kauri Creek Conservation Park #s 1,4; Bullock Creek Conservation Park #28). Here, mud mounds were constructed in and around the remains of the stump such that the timber appeared to act as internal reinforcing for the completed structure.

Occasionally the local landform at sites with tree trunk nests prevented individual nests fitting neatly into the standard habitat zonation scheme. In these cases, Table 5 provides simple descriptive terms for the physical location/vegetation at the nest site. For example, 'woodland/sedgeland' was applied to situations where a distinct supralittoral bank was lacking at the boundary between the intertidal area and adjacent *Melaleuca quinquenervia* or *Casuarina glauca* woodland. The term 'woodland tongue' was applied to a promontory of dry land that lay between areas of mangrove and saltmarsh. The overall landform and the size of the tongue made it too big to be considered an island and its situation within the intertidal zone ruled out the possibility of it being termed a true supralittoral bank.

Visible mud heights in Type 4 nest structures reached 86cm above the surrounding littoral substrate (Coomera River #80), but in some cases may have been higher in the concealed cavities inside the trunks. Nest #98 at South Stradbroke Island, a small mound inside a wide, hollow

FIG. 10. A tree nest in the trunk of a living *Avicennia marina* (nest #12, Noosa North Shore, April 1997). Photo Ian Gynther.

TABLE 4. Supralittoral bank nests (Type 3) of *Xeromys myoides* from southeast Queensland. Abbreviations: M, height of mound structure, if present; B, height of supralittoral bank; H, total nest height, i.e. M+B; Circ., basal circumference of any mounding; indet., indeterminate. Hole heights are measured from the bank base. * The term 'sedge' refers to the combination of *Juncus kraussii* and *Baumea juncea*.

Ref. No.	Locality	Lat (S)	Long (E)	M/B (cm)	H (cm)	Circ. (m)	Material	Holes	Veg. Cover
7	Noosa North Shore	26°23'10"	153°04'10"	16/64	80	1.9	sand	2; 63cm, 68cm	*C. glauca* (8m)
8	Noosa North Shore	26°23'12"	153°04'11"	20/43	63	1.6	peat/sand	2; 2 @ 43cm	*S. virginicus*, sedge*
24	Gallagher Pt	27°00'20"	153°05'59"	43/27	70	4.1	loam/sand	2; 27cm, 45cm	*S. virginicus*, *J. kraussii*, *C. glauca* (8m)
25	Gallagher Pt	27°00'29"	153°05'52"	?/?	38	3.8	loam/white sand	5; 2 @ 2cm, 6cm, 17cm, 38cm	*S. virginicus*, *J. kraussii*, *B. halimifolia*
26	Gallagher Pt	27°00'31"	153°05'52"	21/39	60	4.1	loam/white sand	2; 2 @ 0cm	*S. virginicus*, *J. kraussii*, *C. glauca* (4m)
31	Donnybrook	27°00'56"	153°02'56"	44/?	?	4.3	peat	11; 5 @ 8+?cm, 4 @ 15+?cm, 2 @ 18+?cm	burnt (?*S. virginicus*), *C. glauca* (4m)
32	Donnybrook	27°00'57"	153°02'56"	25/32	57	5.0	clay/humus	9; 0cm, 2cm, 4cm, 15cm, 33cm, 34cm, 2 @ 38cm, 47cm	*S. virginicus*
33	Donnybrook	27°00'58"	153°02'55"	38/?	?	6.8	?peat (burnt out)	5; 2 @ 8+?cm, 15+?cm, 16+?cm, 30+?cm	burnt (?*S. virginicus*), *C. glauca* (4.5m)
35	Donnybrook	27°01'01"	153°02'59"	25/50	75	3.4	sand/clay	3; 2 @ 25cm, 30cm	nil
39	Donnybrook	27°01'09"	153°03'08"	20/30	50	2.2	sand/clay	5; 2 @ 0cm, 15cm, 35cm, 40cm	*S. virginicus*
40	Donnybrook	27°01'11"	153°03'13"	?/?	35	3.1	sand/loam	5; 2 @ 0cm, 2cm, 10cm, 15cm	nil
41	Donnybrook	27°01'11"	153°03'14"	24/40	64	2.8	sand/clay	4; 0cm, 40cm, 45cm, 55cm (plugged)	*S. virginicus*
53	Rainbow Channel	27°27'28"	153°25'43"	10/30	40	2.2	peat/mud/ sand	2; 0cm, 30cm	*J. kraussii* (1m), *Imperata cylindrica* (1m)
54	Rainbow Channel	27°27'29"	153°25'43"	0/35	35	N/A (no mound)	nil	1; 8cm	sedge*
55	Rainbow Channel	27°27'30"	153°25'43"	0/35	35	N/A (no mound)	nil	undetected	tree roots
56	Rainbow Channel	27°27'34"	153°25'43"	30/40	70	3.9	peat/mud/ sand	6; 4 @ 0cm, 2 @ 70cm	*J. kraussii* (1.6m), *M. quinquenervia* (5m)
58	Rainbow Channel	27°27'40"	153°25'40"	30/30	60	3.9	peat/mud	6; 0cm, 4 @ 30cm, 60cm	*J. kraussii*
59	Rainbow Channel	27°27'44"	153°25'49"	10/?	?	1.1	peat/sand	3; ?cm, 2 @ 10+?cm	*J. kraussii*, *Caustis blakei*, *Gahnia sieberiana*
61	Rainbow Channel	27°28'01"	153°25'36"	15/20	35	indet.	peat/mud	2; 0cm, 35cm	*J. kraussii*, *B. halimifolia*
62	Canalpin Ck	27°36'19"	153°24'38"	0/60	60	N/A (no mound)	nil	1; 32cm	*Gahnia* sp., *M. quinquenervia* (11m), *B. halimifolia* (2m)

trunk, was the lowest recorded tree nest at only 25cm. Mean nest height inside tree trunks was 59cm (SD = 18cm, n = 26). Additional plastering of mud against the interior or exterior surfaces of the tree often extended much higher than the nest heights indicated in Table 5. Furthermore, in

TABLE 5. Tree trunk nests (Type 4) of *Xeromys myoides* from southeast Queensland. Abbreviations: CP, Conservation Park; H, height of visible mud structure only (actual nests may be higher inside trunks); Circ., maximum circumference of the tree nest at ground level (where relevant, including extent of any mud mounding or buttress roots used as nest access points); indet., indeterminate.

Ref. No.	Locality	Lat (S)	Long (E)	Veg. Zone	H (cm)	Circ. (m)	Material	Holes	Tree Species
1	Kauri Ck CP	25°46'57"	152°58'24"	sedgeland	35	3.2	peat/black soil/sand	5; 2 @ 0cm, 8cm, 2 @ 20cm	*M. quinquenervia*, dead, Ht. ?, CBH N/A
3	Kauri Ck CP	25°47'01"	152°58'22"	woodland/ sedgeland	28	3.3	peat/sand	5; 5 @ 0cm	*M. quinquenervia*, live, Ht. ?, CBH ?
4	Kauri Ck CP	25°47'06"	152°58'10"	sedgeland	25	1.8	black loam/sand	1; 0cm	*C. glauca*, dead, Ht. ?, CBH ?
11	Noosa North Shore	26°23'41"	153°03'43"	woodland tongue	51	2.7	grey sand	3; 0cm, 8cm, 15cm	*E. agallocha*, dead, Ht 0.6m, CBH N/A
12	Noosa North Shore	26°23'41"	153°03'45"	mangrove	63	1.9	sand	2; 0cm, 9cm	*A. marina*, live, Ht 6.5m, CBH 1.9m
28	Bullock Ck CP	27°00'47"	153°04'11"	sedgeland	45	3.4	mud	6; 2 @ 0cm, 5cm, 15cm, 16cm, 23 cm	*C. glauca*, dead, Ht 0.45m, CBH N/A
30	Donnybrook	27°00'55"	153°03'01"	mangrove	80	0.9	peat/mud	2; 2 @ 0cm	? *A. marina*, dead, Ht 1.8m, CBH 0.95m
36	Donnybrook	27°01'06"	153°03'09"	mangrove	48	3.6	mud	3; 2 @ 0cm, 32cm	*A. marina*, part-live, Ht 8m, CBH 2.8m
52	Rainbow Channel	27°27'22"	153°25'45"	woodland/ sedgeland	indet.	1.3	peat	1; 0cm	*C. glauca*, live, Ht 12m, CBH 1.2m
70	Coomera R	27°50'17"	153°22'49"	mangrove	85	1.1	mud	2; 0cm, 85cm	*A. marina*, live, Ht 6m, CBH 0.8m
71	Coomera R	27°50'22"	153°22'51"	mangrove	indet.	0.7	mud	2; 0cm, 30cm (in wood)	*A. marina*, live, Ht 5m, CBH 0.8m
73	Coomera R	27°50'23"	153°22'53"	mangrove	indet.	0.9	mud	1; 0cm	*A. marina*, live, Ht 5m, CBH 0.8m
75	Coomera R	27°50'24"	153°22'31"	mangrove	60	2.4	mud	1; 30cm	*A. marina*, live, Ht 6m, CBH 0.85m
78	Coomera R	27°50'31"	153°22'22"	mangrove	indet.	1.8	mud	2; 1cm, 2cm	*A. marina*, live, Ht 6m, CBH 0.7m
79	Coomera R	27°50'32"	153°22'37"	mangrove	80	1.7	mud	2; 2 @ 0cm	*A. marina*, live, Ht 6m, CBH 1.1m
80	Coomera R	27°50'35"	153°22'19"	mangrove	86	1.6	mud	3; 3 @ 0cm	*A. marina*, live, Ht 5m, CBH 0.57m
81	Coomera R	27°50'35"	153°22'19"	mangrove	indet.	2.0	mud	4; 0cm, 2 @ 15cm, 30cm (tree hole)	*A. marina*, live, Ht 6m, CBH 0.68m
92	S Stradbroke	27°51'27"	153°25'01"	mangrove	75	1.8	mud/grey-black sand	undetected	*E. tereticornis*, dead, Ht 3m, CBH 1.25m
93	S Stradbroke	27°51'30"	153°25'00"	mangrove	66	3.5	mud/grey-black sand	2; 30cm, 40cm	*E. tereticornis*, dead, Ht 2.1m, CBH 1.3m
94	S Stradbroke	27°51'30"	153°25'00"	mangrove	63	2.6	mud/grey-black sand	2; 2 @ 63cm	*E. tereticornis*, dead, Ht 4m, CBH 1.7m
96	S Stradbroke	27°51'35"	153°25'01"	mangrove	72	3.1	mud/grey-black sand	3; 3 @ 0cm in buttresses	*E. tereticornis*, dead, Ht 1.9m, CBH 1.25m
97	S Stradbroke	27°51'36"	153°25'07"	mangrove	56	4.7	mud/grey-black sand	5; 4 @ 0cm, 20cm	*E. tereticornis*, dead, Ht 1m, CBH 1m
98	S Stradbroke	27°51'37"	153°25'02"	mangrove	25	1.1	mud/grey-black sand	2; 2 @ 0cm under logs	*E. tereticornis*, dead, Ht 1.6m, CBH 1.9m
99	S Stradbroke	27°51'37"	153°25'03"	mangrove	65	3.1	peat/grey sandy mud	2; 2 @ 25cm	*E. tereticornis*, dead, Ht 1.3m, CBH 1.2m
100	S Stradbroke	27°51'38"	153°25'04"	mangrove	54	3.0	mud/grey sand	2; 0cm, 40cm	*E. tereticornis*, dead, Ht 2.8m, CBH 1.5m

TABLE 5 (*Cont.*)

Ref. No.	Locality	Lat (S)	Long (E)	Veg. Zone	H (cm)	Circ. (m)	Material	Holes	Tree Species
101	S Stradbroke	27°51'38"	153°25'04"	mangrove	62	4.2	mud/grey sand	8; 8 @ 0-32cm	*E. tereticornis*, dead, Ht 2.5m, CBH 1.6m
104	S Stradbroke	27°51'40"	153°25'04"	mangrove	35	2.7	mud/grey-black sand	5; 0cm, 4 @ 10cm	*E. tereticornis*, dead, Ht 9m, CBH 1m
105	S Stradbroke	27°51'41"	153°25'04"	mangrove	60	3.1	mud/grey sand	4; 3 @ 0cm, 15cm	*E. tereticornis*, dead, Ht 2.5m, CBH 1.5m
107	S Stradbroke	27°51'42"	153°25'05"	mangrove	60	3.1	mud/grey sand	2; 2 @ 0cm	*E. tereticornis*, dead, Ht 3m, CBH 2.1m
108	S Stradbroke	27°51'42"	153°25'05"	mangrove	60	2.5	mud/grey-black sand	5; 5 @ 0-25cm	*E. tereticornis*, dead, Ht 3m, CBH 2.3m
109	S Stradbroke	27°51'44"	153°25'04"	mangrove	85	4.3	grey sand	5; 5 @ 0cm (1 in buttress)	*E. tereticornis*, dead, Ht 8m, CBH 1.55m

small diameter trees mud plugging of knot holes and other gaps in the tree's outer walls were sometimes seen at considerable heights. In one ease at Coomera River (#81), a plugged knothole was noted 1.75m above ground, while other holes at heights of 1.4m and 1.1m were also blocked with mud.

Up to eight entranee holes were reeorded in tree trunk nests but, given the number of exposed 'buttress' roots through whieh aeeess to some nests might have been gained, this total was probably an underestimate. Other tree nests had no visible access points in the trunk or roots but did possess mud mounds with entrance tunnels constructed against the base of the trunk. Reeorded examples of such mounds ranged in height from 10-42cm and contained 1-3 access holes, sometimes with fluted entrances. These mounded struetures were of insuffieient height to represent nests themselves but appeared to provide aeeess to one or more holes in the nest tree at or near ground level. This was not eonfirmed in any of the doeumented eases beeause it would have necessitated destroying the associated mound.

Beeause of the location of many of this extraordinary range of tree trunk nests deep within the mangrove eommunity (up to 265m from the landward mangrove zone edge), most experieneed longer periods of inundation and deeper moating than other *X. myoides* nest types. The only tree trunk nests recorded that did not reeeive 360° moating during the tidal eyele (Noosa North Shore #11; Rainbow Channel #52) involved trees standing on the supralittoral bank. In both cases, the maximum extent of moating experienced at high tide was 180°.

5. Spoil Heap Nests. Spoil heap nests were those constructed in human-made piles of excavated or bulldozed earth (Fig. 14), soil clods among roots of bulldozed trees or in the bund walls associated with drainage or flood mitigation works (Fig. 15). Such artificially ereated features provided elevation above the surrounding intertidal communities and the level of spring tides.

FIG. 11. Mounding at the base of a living (hollow) *Avicennia marina* (nest #81, Coomera River, November 2001). Photo Ian Gynther.

FIG. 12. Details of mud plugging of hole in trunk of same living *Avicennia marina* depicted in Fig. 11 (nest #81, Coomera River, August 2001). Photo Ian Gynther.

Eighteen nests were recorded in human-made bund walls or spoil piles (Table 6). Spoil heap nest heights ranged from 40-89cm (mean = 56cm, SD = 15cm, n = 18). Although examples of Type 5 nests were discovered within each intertidal vegetation community, the majority was in *Sporobolus* grassland, a community that receives a high incidence of human-related impacts because of closer proximity to adjacent land uses. All spoil heap nests identified during this study would have experienced 360° moating during spring high tides.

At Maroochy River (Fig. 14) and Donnybrook, nests #13 and #46, respectively, were constructed in combined soil and tree stump waste that had been bulldozed to near the landward edge of the mangrove woodland, presumably during construction of vehicle tracks. The spoil heap associated with the nest at White Patch on Bribie Island (#47) resulted from a firebreak being bulldozed through the wallum vegetation to the edge of the intertidal zone. Similarly, all nine Type 5 nests discovered on the north bank of the Coomera River were in spoil piles created during past clearing of the site for a development that was then temporarily abandoned. Some of the piles included rock, gravel and even concrete debris (nest #s 86,88,90,91).

At Steiglitz, four nests were found in spoil heaps originating from the soil associated with the exposed roots of upturned trees or from excavation activity during the construction of a high-banked drainage channel. All piles were thickly covered with Marine Couch. Large heaps with circumferences of 7.3-7.6m (nest #s 65, 67) were richly pocked with access holes (19 and 20 holes, respectively) and heavily scored (beneath the couch) with mud tracks created by the animals (see Fig. 20). These nests were close (approximately 130m) to the site of an intensive marina development. The structurally simple mangrove community associated with the Steiglitz nests was probably not older than thirty years. In the mid-1960s, elevation of the nearby existing main road (90m to the southwest), together with the introduction of tidal gates on the

FIG. 13. Mounding on dead, hollow, horizontal trunk of living *Avicennia marina* (nest #80, Coomera River, November 2001). Photo Ian Gynther.

FIG. 14. Spoil heap nest in bulldozed material (nest #13, Marooehy River, Mareh 1996). Photo Ian Gynther.

Behm's Creek bridge (700m to the southeast) resulted in the site undergoing an ecological succession from a *Casuarina glauca/Sporobolus virginicus* community to one dominated by *Aviceuuia mariua/S. virginicus* (G. Leiper, pers. comm.). Numerous dead *C. glauca* stags remain today. The 1m-high drainage channel wall, approximately 10m north of the spoil pile nests did not show any evidence of nesting activity. This was not the case at the Pimpama River locality, where the single recorded nest (#69), discovered by Peter Lehmann during a radio-telemetry study, was constructed in the spoil bank created during excavation of a drainage channel (Fig. 15). This channel emptied directly into the Pimpama River, 33m from the nest site.

All Type 5 nest sites were within highly disturbed areas or in close proximity to such areas. In addition to the White Patch and Coomera River sites mentioned above, the Marooehy River nest (#13) was approximately 16m from a road skirting a sugar cane plantation, nest #46 (Donnybrook) was approximately 5m from a vehicle track and a now felled, exotic pine plantation, and all Steiglitz nests occurred in an area less than 200m wide between an artificial channel draining an abandoned sugar cane plantation and a road bordering a marina development. Nest #68 (Jacobs Well) was built in a large (9m x 11m) spoil heap, 17m from the boundary of a commercial nursery on the main Jacobs Well Road.

NEST RECOGNITION. With some experience, most active or recently active *X. myoides* nests belonging to each nest class described above could be identified with confidence by considering a combination of the following features: the overall height of the nest, the size and shape of any associated mounding, the existence of additional workings including mud or peat plastering and tracks, and the presence and nature of access holes. The small percentage of *X. myoides* nests that could not be detected or reliably identified using visual search techniques included those constructed in the supralittoral bank without any additional associated mounding. It was necessary to locate these using radio-telemetry techniques because the profusion

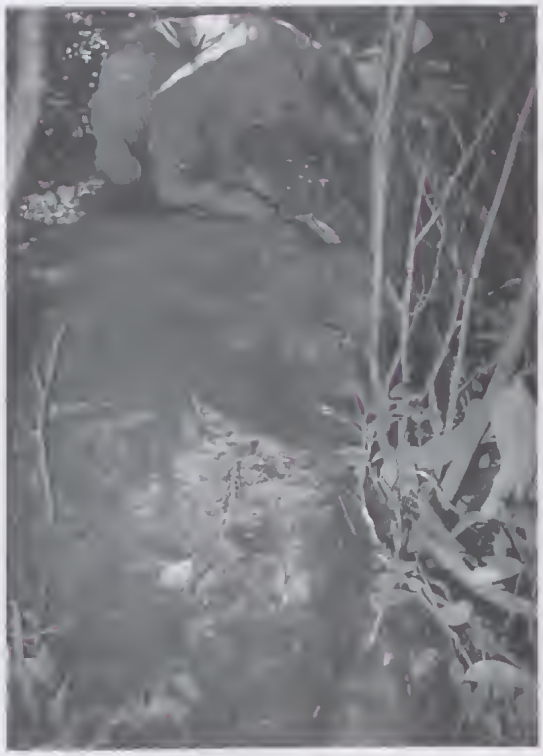

FIG. 15. Spoil heap nest in material excavated from a drainage channel (nest #69, Pimpama River, July 1995). Photo Ian Gynther.

TABLE 6. Spoil heap nests (Type 5) of *Xeromys myoides* from southeast Queensland. Abbreviations: H, height of the spoil heap plus any additional mounding; Circ., basal circumference of the spoil heap.

Ref. No.	Locality	Lat (S)	Long (E)	Veg. Zone	H (cm)	Circ. (m)	Material	Holes	Veg. Cover
13	Maroochy R	26°38'20"	153°04'18"	*Sporobolus*	67	16	stump/clay/ loam	8; 4 @ 0cm, 2 @ 18cm, 20cm, 22cm	nil
46	Donnybrook	27°01'22"	153°03'12"	chenopod	89	24	stump/clay (later burnt)	7; 2 @ 25cm, 30cm, 56cm, 70cm, 2 @ 89cm	*S. virginicus*
47	White Patch	27°01'40"	153°06'59"	sedgeland	45	6.8	peat/loam	9; 3 @ 0cm, 8cm, 2 @ 10cm, 30cm, 34cm, 40cm	*J. kraussii*, *Phragmites australis*
64	Steiglitz	27°45'20"	153°20'29"	*Sporobolus*	44	3.0	peat/sand	12; 2 @ 4cm, 5cm, 2 @ 10cm, 3 @ 13cm, 14cm, 15cm, 17cm, 21cm	*S. virginicus*
65	Steiglitz	27°45'21"	153°20'28"	*Sporobolus*	60	7.6	sand/loam	19; 5 @ 0cm, 7cm, 8cm, 9cm, 2 @ 10cm, 2 @ 11cm, 2 @ 12cm, 15cm, 20cm, 30cm, 37cm, 42cm	*S. virginicus*
66	Steiglitz	27°45'21"	153°20'28"	*Sporobolus*	53	2.6	sand/loam	7; 5cm, 7cm, 2 @ 8cm, 11cm, 14cm, 15cm	*S. virginicus*
67	Steiglitz	27°45'24"	153°20'25"	*Sporobolus*	80	7.3	stump/peat/ sand	20; 0cm, 2 @ 8cm, 2 @ 14cm, 3 @ 15cm, 16cm, 2 @ 17cm, 2 @ 18cm, 3 @ 20cm, 21cm, 22cm, 53cm, 64cm	*S. virginicus*, *C. glauca* (4m)
68	Jacobs Well	27°46'22"	153°21'16"	*Sporobolus*	50	2.6	peat/sand	4; 10cm, 15cm, 21cm, 45cm	*S. virginicus*
69	Pimpama R	27°48'18"	153°20'21"	mangrove	45	12.6	peat/mud	8; 5 @ 0cm, 3 @ 45cm	nil
82	Coomera R	27°50'35"	153°22'20"	mangrove	47	3.6	peat/mud/ sand	3; 15cm, 30cm, 33cm	*S. virginicus*
83	Coomera R	27°50'39"	153°22'17"	mangrove	45	3.0	peat/mud/ sand	2; 24cm, 32cm	*S. virginicus*, *S. quinqueflora*
84	Coomera R	27°50'39"	153°22'19"	mangrove	44	3.1	peat/mud/ sand	1; 0cm	*S. virginicus*, *S. quinqueflora*
85	Coomera R	27°50'51"	153°22'20"	*Sporobolus*	40	3.8	peat/mud/ sand	2; 2 @ 0cm	*S. virginicus*
86	Coomera R	27°50'51"	153°22'22"	*Sporobolus*	45	3.3	clay/mud/ gravel	7; 0cm, 5cm, 19cm, 20cm, 24cm, 2 @ 29cm	*S. virginicus*
88	Coomera R	27°50'54"	153°22'26"	*Sporobolus*	62	8.1	mud/gravel/ rock	8; 3 @ 10cm, 40cm, 43cm, 2 @ 49cm, 55cm	*S. virginicus*
89	Coomera R	27°50'55"	153°22'21"	*Sporobolus*	40	4.5	heavy loam	4; 2 @ 0cm, 15cm, 30cm	*S. virginicus*
90	Coomera R	27°50'55"	153°22'26"	*Sporobolus*	64	7.2	mud/gravel/ rock	6; 12cm, 17cm, 25cm, 30cm, 36cm, 47cm	*S. virginicus*
91	Coomera R	27°50'56"	153°22'28"	Sporobolus	80	11.1	mud/gravel/ debris	3; 5cm, 21cm, 31cm	*S. virginicus*, *S. quinqueflora*

of crab holes that occurred in supralittoral banks made positive visual identification of nest entrances impossible. Also, nests that had been abandoned for a long period of time were difficult to identify with confidence because all external signs of occupation (holes, tracks, plastering, etc.) had disappeared. As an illustration of this, only one abandoned nest (a free-standing mound designated as Stockyard #63) could be reliably attributed to *X. myoides* during this study. This was because its history of occupation was known.

The various features that aid in the identification of *X. myoides* nesting structures are described in more detail here.

Overall Nest Height and Moundings. For all *X. myoides* nest types, a plot of the overall heights of nests above the surrounding substrate of the intertidal zone revealed an approximately normal distribution. The mean height of extant nests across all nest classes was 53cm (range = 25-89cm, SD = 16cm, n = 101). Two-thirds of these occupied nests had heights within the range of 31-60cm, with only 7% and 27% of nests being smaller or larger, respectively. This typical size

FIG. 16. Diagram of intertidal community zonation from the supralittoral bank (top) to the marine mudflats showing the variety of *Xeromys myoides* nesting strategies documented from the 110 nests encountered during this study. The numbers represent totals for each nest type recorded within each zone.

range provides a useful guide when assessing whether potential nest structures encountered during survey work belong to *X. myoides*.

All nest types involved, or could incorporate, characteristic moundings of mud or other substrate material. The mound structures associated with free-standing nests ranged up to 66cm in height and were often conspicuous in their surroundings because the mound accounted for the nest's total height. However, those found in association with island, supralittoral bank or spoil heap nests were generally smaller in all dimensions because the raised substrate on which the nest was located already provided substantial elevation and, therefore, protection of the nest against high tides. In all cases, however, the overall profile of the mounded structure was similar—approximating an inverted paraboloid.

In situations of tall or dense vegetation, mounded structures created by *X. myoides* were much easier to detect and identify where fires had recently burned the survey area. This was true for mounds associated with island nests (Fig. 17) but was particularly so for the large mud mounds of free-standing nests and those on the supralittoral bank that would otherwise have been concealed by surrounding sedgeland (Fig. 18).

In the area of southeast Queensland in which this study focused, the naturally occurring structures most likely to be mistaken for *X. myoides* nests were various mounds made by intertidal crab species. The most frequently encountered were the low, irregular mud mounds found in the outer (more seaward) portions of the mangrove community, usually amongst stands of *Rhizophora stylosa*. These were created by *Neosarmartium trispinosum* and *Perisesarma messa*. Two main indicators that these were not Water Mouse nest structures were the abundance of such mounds (at times covering large areas amid the mangroves) and their limited height (most <25cm). Given their position in the intertidal zone, it was quite apparent that even the tallest of these structures would be entirely inundated at high tide. Nevertheless, such crab mounds may offer valuable protection to *X. myoides* because many

FIG. 17. A mound associated with an island nest exposed by fire (nest #42, Donnybrook, September 1996). Photo Ian Gynther.

FIG. 18. A mound associated with a supralittoral bank nest exposed by fire (nest #61, Rainbow Channel, North Stradbroke Island, September 1997). Photo Steve Van Dyck.

captured individuals ran into these holes upon release from our traps.

Plastering and Tracks. The tops of mounded structures associated with active *X. myoides* nests often bore signs of recent 'earthworks' in the form of plastering or daubing. This frequently involved additions of a mud or peat slurry that, over time, gradually served to increase the mound's overall height. In other cases, the material added was not as fluid, instead forming a peaty layer in which small (<1cm diameter), roughly spherical balls of substrate were compacted together (see Fig. 18). In whatever form it took, the fresh daubing was often worked into and among the bases of living stems of sedges or *Sporobolus* to a height of many centimetres (see Fig. 18).

The style of plastering used by Water Mice to add height to their mound structures was also used to repair any damage to the top or sides of the mound. For example, where Feral Pigs *Sus scrofa* had breached the side of a free-standing nest at Pumicestone Passage (#21), the resulting hole was plugged with newly added peat material of a markedly different colour and texture to the surrounding mound, indicating it had come from a different source and was added later. Another example from Gallagher Point, Bribie Island is shown in Fig. 19.

Plastering and daubing were also features of tree trunk nests. In fact they were often the only visible evidence of nesting activity in trees because the very nature of such nests often made it impossible to see the full extent of the workings within the hollow trunk or stump. At times, mud or peat packing could be seen inside the tree's hollow chamber when viewed from above (see Fig. 10) or by examining knot holes or openings left where trunks or branches had broken off. The use of plastering in such situations was similar to the plugs constructed following damage to other *X. myoides* nest types. Mud workings associated with tree trunk nests also included mounds with access holes constructed against the trunk at ground level (Fig. 11, see above). Nest #80 at Coomera River, with its small mound of mud adorning the upper surface of a horizontal section of trunk well above ground (Fig. 13), represented a more exaggerated example of plastering.

FIG. 19. Repair work to damaged nest mound (nest #24, Gallagher Point, Bribie Island, March 1999). Photo Steve Van Dyck.

FIG. 20. Free-standing nest showing slurry track leading from access hole to mound top (nest #17, Pumicestone Passage, November 1996). Photo Steve Van Dyck.

FIG. 21. Multiple slurry tracks on top surface of nest mound (nest #29, Bullock Creek Conservation Park, March 1999). Photo Ian Gynther.

The material used by *X. myoides* to plaster the tops of nest mounds or repair breaches to mound structures was brought from one or more access holes and then smeared to the site where additions were being made. This action, which in captivity was observed (by SVD) to involve the animal pushing the substrate along with its forefeet, resulted in clearly defined, slurry tracks 5-10cm wide leading to the top of the nest mound (Fig. 20). Breaches in the nest structure were also observed being plugged using the mouth only, with a captive individual putting a plug in place with the bottom of the snout. Often each mound possessed multiple tracks (Fig. 21). By parting the Marine Couch or sedges growing on the mound, these obvious tracks could be traced back to the hole from which the mud, peat or other material had come. The plastering action that must be associated with construction of such slurry pathways was apparent from the way the material used overlaid the bases of grass and sedge stems along the route. Once the track substrate had dried and hardened following application, these tell-tale signs of energetic building activity persisted long after the work was actually performed.

A further feature of *X. myoides* nests useful for confirming identification is the frequent inclusion in the daubing and tracks of whole or partial carapaces of small crabs, particularly *Parasesarma erythrodactyla* and *Helice leachii*, upon which this rodent feeds (Van Dyck, 1997). Although this was most likely an inadvertent action on the part of the Water Mouse, the carapaces would have reinforced the 'mortar' formed by mud, peat or other substrates used in nest construction.

Finally, very fresh tracks, as well as mud or peat daubing, often possessed a distinctive, somewhat acrid aroma characteristic of *X. myoides*. Whether this smell, detectable to us only at close range, was due to the animal's droppings or to deliberate scent marking using secretions from its anal glands was not determined, nor was it ascertained whether fresh workings always bore this odour. Nevertheless, this olfactory evidence proved useful in identifying nests of this species.

Access Holes. All active *X. myoides* nests possessed external holes to provide the animals with entry and exit points. The size, shape, number and positioning of these holes offered clues indicating a potential nest structure did indeed belong to the Water Mouse. The occasional exceptions to this were supralittoral bank nests where no additional mound structure was associated with the nest and some tree trunk nests where ground level access was most likely achieved via existing tunnels in hollow buttress roots. Where present and visible, nest access holes were generally larger in overall diameter than those created by the various southeast Queensland intertidal crabs encountered during this study. They were usually circular or horizontally elliptical. Hole dimensions were not recorded for each nest observed in this study and so summary statistics on size variation are not available. Nevertheless, typical dimensions were 35-38mm in diameter for circular access holes and 35mm wide x 28mm high for elliptical holes. Access holes used by *X. myoides* always gave the appearance of being open, although observations made in captivity revealed that at least some tunnels leading into the nesting chamber within the mound were blocked some way down with a plug of mud 5-8cm in thickness (SVD, pers. obs.). This blockage was not visible from outside the nest. On occasion we discovered holes that had dome-shaped caps of mud or peat sealing the external entrance, but in all such instances the animal responsible was determined to be a crab.

The number of access holes per nest ranged from one to 25. Across all nest types, however, the majority (64%) of nests possessed between one and five access holes, with a further 25% of nests having six to ten holes. Of the remaining nests, 5% had 11-15 holes, 4% had 16-20 holes, and nests with 21-25 holes accounted for only 2% of the total recorded. Based on this frequency distribution, one would only occasionally expect to encounter nests of *X. myoides* with more than ten access holes when conducting nest searches.

Although access holes could be present at any height from ground level to the nest top, the distribution of hole heights for all nest types involving mounded or elevated structures was skewed towards the lower third section of the nest. Consequently, where a structure suspected of being a nest of *X. myoides* possessed multiple holes, additional evidence supporting these suspicions was provided by a higher proportion of holes near the base of the structure.

Access holes showed no obvious difference in size or shape according to their position on the nest. Those at ground level or near the base of a nest structure, however, usually led to tunnels filled with water. As was frequently observed (by SVD) in the captive situation, animals negotiated these flooded passages before entering the nest chambers within. Visible pathways with *X. myoides* footprints leading away from the nest were sometimes detected at ground level access holes, particularly when the surrounding substrate was boggy. These pathways, created through frequent usage by resident animals, often coursed beneath tree roots, dead fall or timber flotsam.

Confusion with other Rodent Activity. It was possible to mistake nests of two other rodent species occupying saltmarsh and mangrove habitats for those of *X. myoides*. Nests of the introduced Black Rat *Rattus rattus* were regularly encountered in the hollow branches and trunks of mangrove trees at heights well above the level of high tide. These nests usually involved obvious collections of dried mangrove leaves, which could be seen through knot holes, broken ends of branches and occasionally down the hollow centres of trunks. Mud, peat or other substrate was never associated with nests of *R. rattus*, but nests often contained crab claws and carapaces. Collections of these crab remains were also encountered in knot holes, branch forks and other recesses in trees thought to represent regular feeding stations used by Black Rats. This suspicion was supported by the identification of hair samples collected from such places as *Rattus* sp. (B. Triggs, pers. comm.). These sites were distinguished from the feeding middens created by *X. myoides* by their presence above ground and by the inclusion of the eaten remains of claws belonging to the crab *Helice leachii*. With a carapace up to 25mm across, this species is probably near the upper size limit of crustaceans preyed upon by Water Mice. Observations in captivity revealed that although *X. myoides* attacked and devoured similar sized species (e.g. *Perisesarma messa*), it did not usually consume the claws, which consequently remained intact (SVD, pers. obs.).

Evidence of activity of a second rodent species, the Swamp Rat *R. lutreolus*, was occasionally discovered in the landward portion of the sedgeland and on the supralittoral bank. This species typically made obvious runways through sedgeland that could be traced for considerable distances among dense ground layer vegetation.

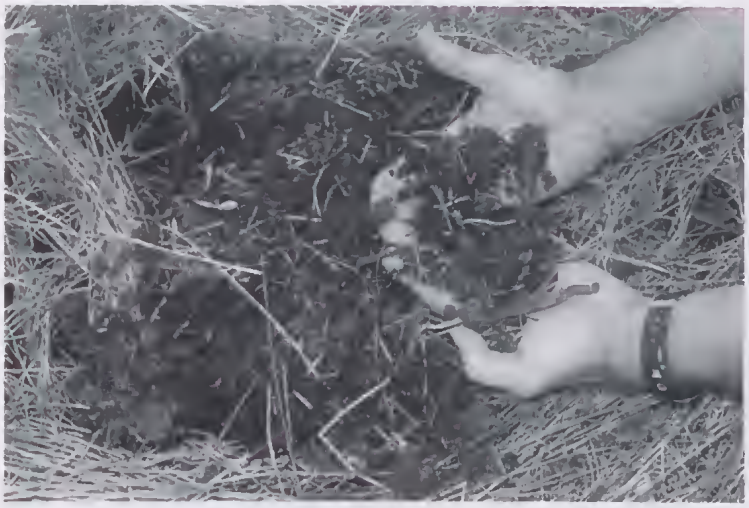

FIG. 22. A pile of spoil created by tunnelling or feeding activity of *Rattus lutreolus* in sedgeland (Coomera River, November 2001). Photo Ian Gynther.

The runways were made more distinct by the Swamp Rat's habit of chewing rushes or sedges along the path, leaving only the stem bases behind. In addition, low mounds or piles formed from *R. lutreolus* tunnel spoil were sometimes encountered. These consisted of a coarse mixture of balls of often peaty substrate and short lengths of chewed sedge stems. The resulting mixture was always much more loosely packed and friable than the substrate found on nests of *X. myoides* (Fig. 22).

DISCUSSION

During our investigation of the Water Mouse's southeast Queensland distribution, we successfully discovered at least one nest structure at all localities at which the species was trapped. This illustrates the considerable value of employing nest search techniques when conducting field surveys. Although the approach is not entirely foolproof, careful searching for evidence of nesting activity of *X. myoides* may represent a more convenient and efficient survey method by comparison to the usual technique of Elliott trapping.

To our knowledge, no other small rodent constructs conspicuous and relatively immense mud nesting mounds after the manner of *X. myoides*. Although comparison of nesting techniques can only be made within a limited field of semi-aquatic rodent genera (see Van Dyck, 1997), it is very likely the preference of *Xeromys* for low altitude, still water, saline conditions and regular tidal fluctuations in water level that has led to the evolution of this unique nesting strategy. In some broad principles of nest construction, however, there are counterparts in lodge-building beavers *Castor canadensis* and muskrats *Ondatra zibethica* from the Northern Hemisphere. Both species gather vegetation into sizeable nesting piles (up to 1.8m and 60-90cm above water level, respectively), which are accessed through underwater tunnels. Of even greater relevance, where earth banks are high enough for dens to be well above water level, or where streams are swift with an accompanying increase in erosional force, both beavers and muskrats dig tunnels into the bank rather than building mounded lodges (Walker, 1964; Burt & Grossenheider, 1976).

Considering the small size of *X. myoides* and the inconvenience that high tides must bring to initial mound construction in the littoral zone, we hypothesise that in situations with a normal tidal range and influence most nests begin in any suitable ground offering sufficient height above the upper tidal level. This would explain the propensity of *X. myoides* for not only colonising the supralittoral bank when one exists, but also raised islands or hummocks, spoil piles, bund walls and clods of earth amongst the roots of upturned trees wherever such features occur in the intertidal zone. However, in exposed situations where minimal buffering is offered by the mangrove community and where no sedges or Marine Couch occur seaward from the supralittoral bank (e.g. Canalpin Creek with its 25m-wide, structurally open mangrove zone), tunnels in the high supralittoral bank may be the only type of nest present. The protection from savage erosion provided by a broad mangrove zone (up to 385m) and abutting zone of sedgeland (up to 32m wide) in locations such as Donnybrook and Rainbow Channel gives the animals time to respond to minor erosion and wet nest chambers by slowly building up nest height with the repeated plastering of mud or peat. Thus examples of additional daubing that formed small

mounds atop the nest were recorded from all nest types encountered during the study. On occasions of extreme high tides, these additions were sometimes the only part of the nest above water level (e.g. free-standing nest #s 76, 87, Coomera River; tree trunk nest #105, South Stradbroke Island) and, by observing through access holes, one or more individuals could be seen occupying these most elevated chambers within the nest structure. During an unusually high daytime tide associated with wind and storm surge at Coomera River, an animal was observed by one of us (SVD) escaping from the hole at the top of the nest and being forced to swim to find alternative shelter. Nearby, an adult female and two young were seen sitting under *S. virginicus* cover on the top of a second nest.

The 'islands' with which Type 2 nests are associated very likely form through erosion of the supralittoral bank. Presumably, the life of such supralittoral offcuts is dependent upon their stabilisation by vegetation cover and their capacity to endure further erosion. When such 'islands' are eventually carved from the supralittoral bank, only those sufficiently consolidated by the roots of trees, shrubs and ground cover may remain as high points, maintaining their integrity in the face of spring tides, wind-induced waves and storm surge. Type 2 nests may then originate through colonisation of such newly available high ground within the tidal zone following the island's formation. Conceivably, though, pre-existing supralittoral bank nests may be sufficiently consolidated within the root mass of trees to be able to persist with the island as it is carved off. This would offer a second possible origin of these island nests.

In highly sheltered locations (e.g., Pumicestone Passage), where spring tides fail to establish a supralittoral bank, free-standing nests, constructed slowly in the absence of frequent inundation or tide damage, predominate. This strategy of constructing large, mounded nests in an area lacking terrain features that would provide sufficient height to offer protection against tides enables *X. myoides* to colonise otherwise uninhabitable locations.

Plastering of nests appears to be performed in response to wet nesting chambers or breaching of the nest's outer wall. This conclusion is supported by the infrequency with which such mud-daubing occurs once a nest is established. Plastering of approximately 20cm diameter increased the height of a bank nest (#53) at Rainbow Channel from nothing to 6cm in 17months. More dramatic plastering events were also noted. On Bribie Island, the height of a mound structure on a spoil pile nest (White Patch #47) increased some 15cm over a maximum period of four months, and perhaps over a time span as short as 3-4 weeks (D. Cameron, pers. comm.). This remarkable rate of construction may have been in response to a period of prolonged inundation due to the combined effects of high rainfall (531.5mm) and tide heights of up to 2.51m in February 1999. Although the rate at which plastering and daubing of a nest structure occurs is undoubtedly dependent upon the number of nest occupants, such events as this at Bribie Island are probably atypical and large, free-standing mounds (e.g., nest #s 14,17,57) may represent decades of effort by generations of mice.

Based on the quantity of substrate that would be required to construct a large, mounded structure, we speculate that most, if not all, of the material used to create the tracks and daubing on the nest's top must originate from substrate layers beneath ground level, i.e. below the nest itself. This would also account for the sometimes different nature of the mound and plastering material as compared to the surface substrate immediately surrounding the nest. The observations of Magnusson et al. (1976) support this hypothesis — in the Melville Island *X. myoides* nesting mound, tunnels 3-5cm in diameter were noted to extend as much as 90cm below ground level. The significant volume of material that must have been excavated during their construction was presumably added to the above-ground mud mound.

The use of spoil piles, clods of soil associated with the roots of fallen trees and hollow tree trunks for nesting provided an insight into the opportunistic way *X. myoides* uses structures that provide nest elevation in situations where it is otherwise in short supply. In addition, tree trunk nesting demonstrated that if a durable framework of support were available Water Mice would occupy the littoral zone well out into the mangrove community. It was apparent, though, that not all hollow trunks offer suitable nesting locations for this rodent. Fourteen of the 31 tree trunk records came from one location on South Stradbroke Island, and these were all from *Eucalyptus* stags. The 'stranding' within the mangrove zone of these large upright stumps, up to 125m from the marine/terrestrial boundary, can be attributed to the rise in water level within

the Southport Broadwater and subsequent erosion and flooding of the low-lying terrestrial community caused by sand sedimentation inside the Broadwater after the breaching of the hitherto connected North and South Stradbroke Islands at Jumpinpin in 1896 (Connah, 1946; Brooks, 1953). That the present day substrate level is lower than it was previously is readily apparent from the exposed root systems of the dead eucalypts. Presumably, by the time the trunks were hollow and accessible to *X. myoides*, the rise in seawater level had not been so great as to prevent nest mounds being initiated within the trees' protective walls. Furthermore, the ongoing rise in water level must have been gradual enough for the mud mounding process to keep abreast of it.

Although the hard-wearing nature of the eucalypt trunks at this South Stradbroke Island site still protects nests today from daily tidal exacerbations, the building of mud structures from 'scratch' in a regularly and deeply flooded location such as this is probably only possible under the special circumstances in which a particular tree offers safe refuge above high tide to a *X. myoides* individual prior to and during the process of nest construction. Of the 12 cases of nests in mangroves reported here, one (Noosa North Shore #11) occurred in the stump of a Milky Mangrove, which, as is typical of this species, was growing at the marine/terrestrial boundary, landward of the main mangrove community. As a consequence, it would have been inundated only very occasionally during the highest of spring tides. The other mangrove nests were, without fail, either in small to large diameter, sloping trunks or in vertical trees of small diameter. In both situations, the nature of the internal hollows presumably enabled the non-arboreal *X. myoides* to scramble up inside, thereby providing dry shelter to the nest-building individuals during the intervening periods of tidal inundation when mound construction within the trunk (or the stopping up of knot holes and other gaps in the tree) could not be undertaken. This may explain why so many apparently suitable mangrove trunks, particularly those of *Avicennia marina*, are not utilised for nesting by *X. myoides*. Their large diameter, hollow bases are usually vertical and simply don't provide opportunities for *X. myoides* individuals to climb up inside.

Although it was obvious when larger diameter nest trees were either mud-filled or contained a mounded mud structure that could house a nesting chamber, it was never unequivocally ascertained whether Water Mice also filled the internal cavities of small diameter trees with mud or other substrate material for this purpose. It is possible that the only mud workings associated with such nests are the plugged external holes that provide nest security whereas the concealed spaces within the narrow diameter trunks and limbs of the tree itself serve as a nesting chamber. This was suggested by the one tree nest example (Coomera #80) where it was possible to view a leaf-filled chamber within a horizontal trunk following damage to the small mud mound that had previously capped the roof. By contrast to large, free-standing mound structures, which would involve considerable effort to build and maintain, the use of such trees that require relatively little mud plastering or packing to convert them into suitable nest sites may make it possible for individual *X. myoides* to occupy nests on a temporary basis or to maintain multiple nest trees within a single home range. Such simple refuges may be utilised by males or newly recruited individuals, i.e. those animals simply seeking shelter rather than somewhere to raise young. Observations in captivity indicated that, in stark contrast to an adult female, a male *X. myoides* used a very basic nest with a chamber lacking any leaves or grass for lining (SVD, pers. obs.). Similarly, an adult male individual caught by hand under a piece of corrugated iron beside the Tomkinson River, Arnhem Land (Magnusson et al., 1976) may have been using the site as a temporary refuge since no nest was found. The fact that certain tree nests were ephemeral in nature was demonstrated by the finding that they were no longer active on our subsequent visits, with some trees even lacking their once tell-tale signs of mud daubing. Presumably not long after a tree nest is abandoned any mud additions fall into disrepair, particularly when these are incapable of being consolidated by vegetation and are submerged and subjected to tidal currents on a frequent basis.

The same gradual rise in sea level that very likely led to the proliferation of tree trunk nests in the eucalypt stags of South Stradbroke Island may also account for the origin of the free-standing mounds (nest #s 95,102,103) that stand amid the sedges and mangrove fern landward of the mangroves at this site, despite the now regular inundation of this section of the intertidal zone. Here, mound construction may also have been able to keep pace with the long term, incremental change in water height that occurred following the break at Jumpinpin. The

extra shelter afforded by the seaward mangrove community, together with the decreased period and extent of tidal inundation in the sedgeland areas as compared to the mangroves, may have allowed nests with no external structural framework, i.e. free-standing mounds, to be built.

Curiously, none of the nests encountered during this study closely matched the description of the original *X. myoides* nest structure from Melville Island provided by Magnusson et al. (1976). It involved a 60cm-high mud mound, containing a nesting chamber, constructed at ground level against the trunk of a living mangrove (*Bruguiera parviflora*) tree. The nest from southeast Queensland that most closely resembled this Northern Territory example was tree trunk nest #81 from Coomera River in which a 42cm-high mud mound was built against the base of a living *Avicennia marina*. Other tree trunk nests with smaller mud mounds were also discovered. However, given the limited size of these mounds, as well as the position of the trees in the littoral zone, the mounds associated with these nests would have been entirely inundated during high tide and so could not serve as nests in their own right. Rather, the purpose of these ancillary mounds may either have been to provide secure access through mud tunnels to the nest proper within the adjacent tree or to serve as a buffer against the tide and thereby prevent mud or organic matter within the tree from washing out through any ground level hole in the trunk. Both explanations may be true. Alternatively, it is interesting to speculate about whether these small mounds built alongside tree nests serve any useful function at all. Because natural selection will have favoured those *X. myoides* individuals that build nest structures above the height of spring tides (the dominant external factor that ultimately must govern nest heights in any region), perhaps animals construct mounds even in situations in which they are not required. Based on our hypothesis about the requirements for nest construction to begin within the mangrove zone, we would assume that the *B. parviflora* adjacent to the nest structure described by Magnusson et al. (1976) was hollow and so able to afford the Water Mice individuals refuge during the mound-building phase.

Trapping and radio-tracking studies have revealed that *X. myoides* regularly follows the receding tide out into the mangrove zone where it feeds until rising water forces it back to the shelter of its nest site (Van Dyck, 1997). This apparent preference for foraging among mangroves suggests this is where food resources for the species occur in the highest densities. This conclusion is supported by studies showing that substrate-dwelling fauna of the mangrove zone is richest in species at the lower tide levels where regular inundation by tides occurs (McCormick, 1978). On first appearances, it would appear sensible for *X. myoides* to nest within the mangrove zone but additional factors come into play. Of all the vegetation communities in the littoral zone, the resource rich mangrove community is the first to be inundated on the flooding tide, and the last to be exposed when the water recedes. Furthermore, the depth of inundation is greater there than anywhere else in the intertidal zone. As a consequence, the time available for a mangrove-nesting *X. myoides* to forage between tides is more limited. We suggest that, overall, nest location, and therefore nest type is a resultant compromise between proximity to the most productive resources of the mangrove zone and a suite of complicating factors, namely the difficulty (or practicality) of nest building in a regularly flooded site, the ability of the nest to withstand tides, particularly spring tides, and the period available for foraging.

In addition to proximity to rich food resources, what other selective advantages may offset the effort in constructing and maintaining large mounds or tree trunk nests within or as close as possible to the productive mangrove zone as opposed to digging simple tunnels into the supralittoral bank near the woodlands and wallum? One possibility is that offspring survival might be higher in complex nest structures attached to high-yielding foraging areas as a consequence of the cumulative effect of home range defence by related adults. This is supported by the incidence of agonistic encounters witnessed between individuals away from nest sites (SVD, pers. obs.). Bank nests, unlike other nest types out in the intertidal zone, are not fully moated at high tide and so may offer less protection from snakes and more opportunities for disruptive intrusion from conspecifics. Additional disturbance may be caused by the foraging activity of *Rattus lutreolus* and predation by *R. rattus* and *Hydromys chrysogaster*. The evening journey between the supralittoral bank and foraging areas within the mangroves may also produce higher losses to nocturnal raptors, Red Foxes *Vulpes vulpes* and Cats *Felis catus*. Finally, fire, the dramatic event that revitalises wallum and coastal woodland by triggering germination, may select those mice that nest far

from its influence. In this regard we have direct evidence in nests #33 and #46 (Donnybrook) that wild fires can quickly convert supralittoral bank nests and adjacent spoil heap nests to peat ash.

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ARTIFICIAL NESTING MOUNDS FOR THE WATER MOUSE, *XEROMYS MYOIDES*. *Memoirs of the Queensland Museum 49(1): 480, 2003:-* In intertidal communities of southeastern Queensland the Water Mouse *Xeromys myoides* constructs nests of five basic types: 1) free-standing mud mounds within areas of sedgeland, chenopod shrubland, Marine Couch *Sporobolus virginicus* grassland or mangrove forest; 2) mounds associated with small, slightly elevated 'islands' standing away from the supralittoral bank; 3) mounds or holes in the supralittoral bank; 4) mud and leaf constructions inside hollow tree trunks; and 5) nests made in spoil heaps of human origin (Van Dyck & Gynther, 2003). Ultimately, the locations (and, therefore, type) of nests constructed by these carnivorous rodents appears to be a compromise between a nest's ability to withstand spring tides and its proximity to the most highly productive resources of the mangrove zone.

Inevitably, some habitats that otherwise would appear suitable for Water Mice either offer insufficient elevation above the surrounding intertidal community or lack suitable hollow tree trunks to allow nest construction and breeding to proceed without inundation. Given the use by *X. myoides* of human-generated spoil heaps for nesting (excavated material, tree stump waste, bulldozed soil, gravel, rock and concrete: Van Dyck & Gynther, 2003), the provision of artificial nesting mounds might represent a useful management tool to encourage this vulnerable species to colonise new sites.

From 5 May - 24 June 1999, 12 artificial nesting mounds were installed on intertidal wetland (centre at 27°50.857'S, 153°22.470'E) close to the Coomera River, southeastern Queensland. The site, although relatively close to an established *X. myoides* population (approximately 400m northwest), presented few natural nesting opportunities. It was characterised by extensive *S. virginicus* grassland flats, a relatively immature mangrove community, a small Swamp Oak *Casuarina glauca* component and an elevation throughout below the 1m contour.

Each artificial nest installation consisted of four copper napthenate-treated hardwood stakes (70mm × 50mm × 2m) set into the corners of a rough, 1 m square and driven into the substrate until about 1.5m of stake remained above ground. Inside the stakes, a cylinder of heavy duty plastic garden trellis (1.2m high, 75mm square lattice pattern) was secured with tie wires. For mouse access, a length of 100mm diameter agricultural pipe with a number of 40mm diameter holes cut along its length was laid on the ground across the middle of the cylinder, each end protruding from the trellis material. (This pipe was later deemed unnecessary — see below.) Commercial potting mix was then tipped in to form a central core of earth and commercial mulch (chipped tree material) was packed around and on top of it to fill the cylinder up to about 1m high (Fig. 1A).

Three artificial mounds were installed among mangroves near the river's edge. Another was positioned on a degraded mud flat, two were installed on low S. *virginicus*/*C. glauca* islands and the remainder (six) were erected in the open *S. virginicus* grassland.

Initially, the artificial mounds were monitored regularly, and as early as 2 June 1999 (three weeks after installation) dismembered crab remains were found on top of two mounds. On 5 August 1999 rodent droppings were retrieved from one mound and later identified as *Rattus* sp. (B. Triggs pers. comm.). By this time it was apparent that all but one mound had been completely inundated by spring tides, and many needed topping up. In particular, the two near the river's edge were rapidly eroding. By 14 October 1999, more droppings were retrieved from another mound, but the occurrence nearby of chewed leaf galls from the mangrove *Avicennia marina* indicated *Rattus rattus* was probably involved. Thereafter, the artificial nests were left unchecked until December 2002, when all 12 mounds were revisited. In all but one, the entire mulch pile inside the trellis cylinders had been washed away. However, one cylinder, installed on a small *S. virginicus* 'island' (27°50.808'S, 153°22.479'E) contained a functional *X. myoides* nest (Fig. 1B). The total nest height (nest mound plus 20cm mud bank) was 47cm, mound circumference was 235cm and three access holes were incorporated into the structure; two at ground level and one at 20cm (at mound base). The mounding material was mostly sand and mud but clearly contained traces of the original soil and mulch provided. Much of the surface of the mound was consolidated by *S. virginicus*, and, as is typical of this rodent, small claws and carapaces of crabs (here, the Mottled Shore Crab *Paragrapsus laevis*) were incorporated into the external mud daubing. The agricultural pipe access was completely blocked with mud.

The provision of such nesting frames, furnished instead with more robust trellis and a much less friable soil, may not only expand the area of habitat available to the species but may become increasingly important at sites where foxes and feral pigs are a potential threat to the nesting success or existence of local *X. myoides* populations.

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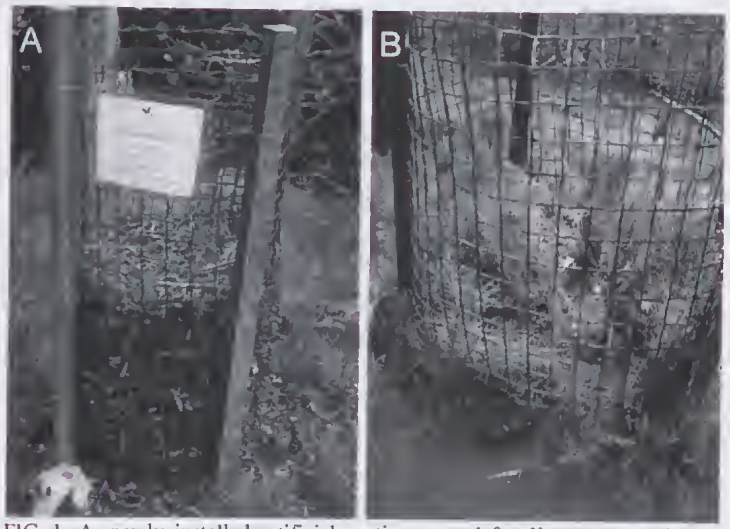

FIG. 1. A, newly installed artificial nesting mound for *Xeromys myoides*. B, functional *X. myoides* mound within artificial nesting frame.

DIABOLICORIS, A NEW GENUS IN THE TRIBE PLOIARIOLINI (HEMIPTERA: REDUVIIDAE: EMESINAE) FROM NEW CALEDONIA

M.A. WALL AND G. CASSIS

Wall, M. A. & Cassis, G. 2003 06 30: *Diabolicoris*, a new genus in the tribe Ploiariolini (Hemiptera: Reduviidae: Emesinae) from New Caledonia. *Memoirs of the Queensland Museum* **49**(1): 481-483. Brisbane. ISSN 0079-8835.

Diabolicoris saicelloides new genus and new species is described and placed in the emesine tribe Ploiariolini. The species is known from a single specimen collected in New Caledonia. *Diabolicoris saicelloides* shows close affinities to *Saicella* Usinger, a flightless genus endemic to the Hawaiian Islands. ❐ *thread-legged bugs, assassin bugs, Diabolicoris saicelloides, new species, Reduviidae, New Caledonia.*

Michael A. Wall, Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA; Gerasimos Cassis, Centre for Biodiversity and Conservation Research, Australian Museum, Sydney 2000, Australia; 3 November 2002.

The Ploiariolini (Hemiptera: Reduviidae: Emesinae) is supported by several synapomorphic characters in the wings, as well as those in the male and female genitalia (Wygodzinsky, 1966). While apparently monophyletic, the position of the Ploiariolini within the Emesinae is ambiguous. Wygodzinsky (1966) considers the Ploiariolini unplaced in the Emesinae, but tentatively allied it with the Emesini, Metapterini and Deliastini. Based on its pronotal glands, we suggest the Ploiariolini may be allied with the emesine tribe Collartidini and the subfamily Saicinae. Furthermore, *Saicella* Usinger, a flightless ploiarioline endemic to the Hawaiian Islands, shares several characters with the Saicinae (e.g. elongate spines on head, labium, procoxae and profemora; procoxae relatively short; and anterior acetabula sometimes directed ventrally) and the Ploiariolini (Wygodzinsky, 1966; Polhemus, 2000). Until now, *Saicella* has been the only ploiarioline known to possess numerous transitional characters. Here we describe a new genus of Ploiariolini from New Caledonia, *Diabolicoris*, that has many of the same transitional characters.

Diabolicoris Wall & Cassis gen. nov.
(Fig. 1)

TYPE SPECIES. *Diabolicoris saicelloides* Wall & Cassis.

ETYMOLOGY. Latin for devil and bug, due to general diabolically spiny appearance of the bug.

DIAGNOSIS. Similar in appearance to *Saicella*, but with spines on trochanter of prolegs and spines absent from procoxae. Also, forewings with triangular subbasal cell, and discal cell distally not lobed.

DESCRIPTION. Macropterous. Body shining, moderately covered in golden flexuous setae. No woolly setae present.

Head short; distinctly divided into anteocular and postocular portions; anteocular region roughly parallel-sided dorsally; postocular region slightly shorter than anteocular, globular both laterally and dorsally with shallow sulcus dorsally, as wide as combined width of eyes and anteocular region; eyes small, set laterally, well below dorsum of head; antenniferous tubules large;ocelli absent; buccula with single posterior spine-like seta; gena with three spine-like setae; labium 3-segmented, segment I subcylindrical with 2 + 2 spine-like setae, equal in length to segment II and III combined, segment II inflated with 3 + 3 setae.

Pronotum covering mesonotum, anterior and posterior lobes present, deeply constricted before midline; anterior lobe subglobular, deeply divided into two elevated lobes by deep median longitudinal sulcus, ostiole of pronotal gland present on sulcus; anterior acetabula directed slightly forward; posterior lobe subquadrate, lateral margins weakly divergent posteriorly. Scutellum barely exposed, semicircular, slightly raised medially. Metanotum as long as hind lobe of pronotum, with a short, stout, apical spine.

Forewings broadly rounded distally with small notch at M and wing margin. Discal cell large, truncate proximally, curved apically. M and Cu fused basally of discal cell forming a triangular subbasal cell. Pterostigma narrow, short, barely surpassing the costal margin of the discal cell. Hindwings present.

Prolegs stout; coxae simple, less than 4 × longer that wide; trochanters armed with two

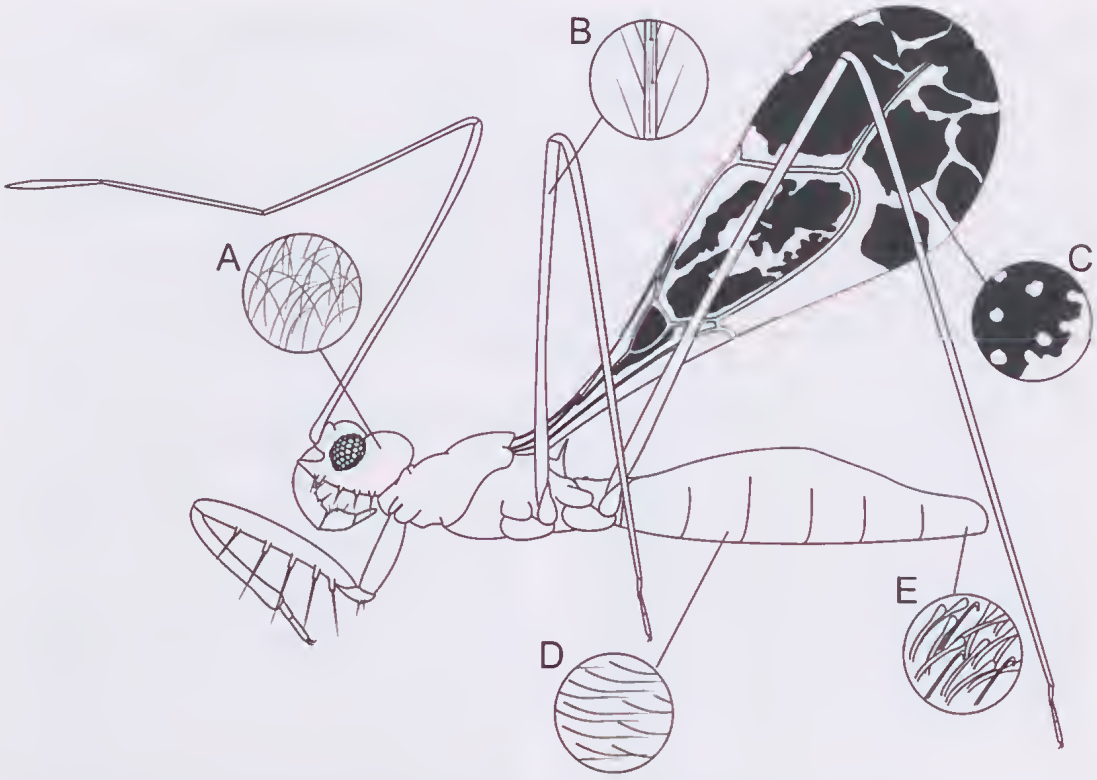

FIG. 1. Lateral view of holotype of *Diabolicoris saicelloides* with selected detail. A, flexuous setae of head and pronotum; B, distally oriented stiff setae of meso- and metalegs; C, areolated pattern elements of forewing; D, appressed setae of abdomen; E, capitate setae covering female genitalia.

obvious spines set on tuberculate bases; femora with row of five enlarged elongate spines set on large tuberculate bases along exterior lateral face, length of longest spine half as long as femur, also with row of six slightly smaller spines along interior lateral surface, angle between interior and exterior rows of spines greater than 90°, distal third of femur with minute dark papillae; tibia with two parallel rows of numerous spinelike setae on ventral surface; tarsus 2-segmented, second segment 2× longer than first; paired claws minute. Middle and hind legs slender with distally angled stiff setae, tarsi 3-segmented, first segment tapered distally, shorter than other segments, junction of second and third segment difficult to discern.

Abdomen broadly attached to thorax, elliptical; connexival margins curved inward; first visible sternite subquadrate, posterior margin shallowly concave, spiracle distinctly stalked.

REMARKS. *Diabolicoris* represents a unique combination of character states, some shared with *Saicella*, others with *Emesopsis* Uhler, and others are possessed by all three genera. *Diabolicoris* resembles the Hawaiian endemic genus, *Saicella*, in the possession of elongate spines on the profemora, labium, and venter of the head. Unlike *Saicella*, *Diabolicoris* is macropterous. The proximally truncated discal cell of the forewing allies *Diabolicoris* with *Emesopsis* and related genera. Wygodzinsky (1966) concluded that *Saicella* and *Emesopsis* are closely related based on characters associated with the phallus, vestiture, and abdomen. Although the question bears further phylogenetic analysis, *Diabolicoris* appears closely related to the *Saicella-Emesopsis* clade proposed by Wygodzinsky (1966).

DISTRIBUTION. Currently only known from the type locality in southern New Caledonia.

Diabolicoris saicelloides Wall & Cassis sp. nov. (Fig. 1)

MATERIAL. Holotype. ♀, NEW CALEDONIA 22 14 S 166 52 E, Chute Madeleine, 230m, 12 November 2000,

GB Monteith, pyrethrum, trunks and logs, 9917. (Muséum National d'Histoire Naturelle - Paris; don no. 1097 du 23.05.2003)

ETYMOLOGY. Named for the genus *Saicella* which it resembles.

DESCRIPTION. (All measurements in mm). Length: 2.4. Ground color aureous to stramineous; antenniferous tubercles and tarsi white; antennae testaceous; meso- and metalegs becoming testaceous distally. Wing with conspicuous testaceous pattern elements.

Head length/width: 0.48/0.28; covered with appressed and upright flexuous golden setae; eyes small, elliptical, longest along dorsoventral axis, approximately 25 ommatidia each; antennal segments length: 1.14/0.84/0.48/0.32, first segment widest distally.

Pronotum length/width: 0.42/0.36, procoxae length/width: 0.28/0.08, profemora length: 0.62, protibiae length: 0.46, protarsi length: 0.12, mesofemora length: 1.28, mesotibiae length: 1.66, mesotarsi length: 0.14, metafemora length: 1.74, metatibiae length: 2.44, metatarsi length: 0.14, and forewing length: 2.14.

Abdomen elliptie in dorsal view, length: 1.5; external female genitalia obscured by thick hyaline capitate hairs; male unknown.

DISTRIBUTION. Known only from Chute Madeleine, New Caledonia. Although this area is primarily dry/selerophyllous maquis-type vegetation, *Diabolicoris saicelloides* was collected from tree trunks in a nearby pocket of rainforest. Subsequent pyrethrum collecting at the same location by the same collector in November 2002 failed to yield more specimens.

ACKNOWLEDGEMENTS

Sincere thanks to Geoff Monteith of the Queensland Museum, who collected and loaned this material to us. This project was completed while the senior author was in Australia on a U.S. Department of State Fulbright Fellowship and supported by the Australian-American Fulbright Commission. The Australian Museum Trust is thanked for supporting this work.

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VOCALISATION BY THE COMMON EASTERN AUSTRALIAN GECKO, *GEHYRA DUBIA*. *Memoirs of the Queensland Museum 49(1): 485-6. 2003:-* Information on vocalisation in Australian geckos is scant. A handful of native species are known to call and one introduced to Australia, the house gecko, *Hemidactylus frenatus* Dumeril & Bibron, 1836, has a loud distinctive call. Most calls reported for Australian geckos have been related to fighting, (e.g. *Diplodactylus* – Bustard, 1965; *Gehyra* – Bustard, 1969; Frankenberg & Werner, 1984), or confrontation with a predator (e.g. *Christinus* Daniels et al., 1986; *Nephrurus asper* – Bustard, 1967; Greer pers. obs., 1989; *Phyllurus platurus* – Greer pers. obs., 1989). On Boyne Island, in Central Queensland, *Gehyra dubia* Macleay, 1877 is commonly found in acacia, eucalyptus woodlands and the surrounding urban areas. This gecko is usually arboreal and is frequently observed on the walls of houses, both in and outside, and other domestic structures.

During late September, 1997, I recorded the calls produced by *Gehyra dubia* specimens for the first time. This was achieved by holding 4 captive *G. dubia* (sample 1, 3♀, 1♂) in two small, transparent containers. Two geckos were placed in each container and microphones were secured to the lids. The outputs from these two microphones were connected to a stereo cassette recorder. At night, between the 23-27/9/97, a series of ½hr recordings was made. This was followed by recordings during late October 1997 (sample 2- 2♂, 2♀), mid February 1998 (sample 3- 2♂), late January 2001 (sample 4- 2♂), and late September 2001 (sample 5- ♂, ♀). Sample 6, early June 2003 (4♀, 2♂), was not recorded, but closely observed to establish if both sexes produced all three calls. Four ♀♀ were placed in one container, and the 2 ♂♂ in another.

Examination of these recordings and my observations between 1989-2003 indicate that *Gehyra dubia* has at least three distinct calls: a distress call, a chirp and a fast chatter. These recordings have been digitised (AWE Sound Blaster Card; Sampling rate, 44,100, 22,050, 11,025; sampling size 16 bit), and reproduced into audiographs (Fig. 1A-C). This has enabled accurate measurements of the call duration (in seconds) and a comparison of the amplitude of pulses within a call. Individual pulses and number of pulses per call were verified by reducing the play-back sampling rate to 11,025Hz. The dominant frequency band of individual pulses (the frequency at which most sound energy is transmitted), and pulse width was achieved by using a freeware dual channel audio spectrum analyser (Gram 50 program). This provided a scrolling time-frequency display (Fig. 2A-C). Only recordings of high resolution were used for frequency analysis and pulse width measurements.

Although these recordings are of the calls of captive geckos, calls are consistent with those heard in the wild. Reasons for these vocalisations are unknown. It was possible to distinguish between the sexes of adults by examining the neck and cloacal regions of each specimen: males lack obvious endolymphatic calcium stores; have distinct preanal pores aligned in an inverted 'V'; distinct postcloacal sacs and enlarged postanal tubercles. Females have distinct endolymphatic calcium stores, moderate postanal tubercles, but lack preanal pores and expanded postcloacal sacs.

Gehyra dubia calls

Type 1 - distress: when fighting, specimens often release a one pulse clamor which is louder and more drawn out than other calls. This was not recorded, but has been displayed by both sexes (sample 6).

Type 2 - the chirp (eee...eee...eee) has been heard frequently. Both ♂♂ & ♀♀ produce this call (sample 6). However, it has been possible to record this call on only three occasions (CH1, CH1a and CHFC1). This call is displayed as a single pulse, or a series of chirps with long intervals between pulses. Recording CH1 (Fig. 1A), 2♀♀, consisted of 6 pulses/ 11.2s; recording CH1a (2♀♀), is of a single pulse; recording CHFC1 (Fig. 1B), ♂ & ♀, multiple chirp portion, 4 pulses/ 5.6s. Estimated, dominant frequency band of individual pulses varies between 2.6-3.8Khz. The pulse width is between 140-228 milliseconds. Pulses peter out at 6.3-8.7KHz.

Type 3 - the fast chatter (ee.ee.ec) is, by far, the most frequently heard, and has been recorded in FC1-11. Adult ♂♂ often exhibit this call (Table 1).

Total pulses per call ranged from 9-23. Pulses per second (pulse rate) varied from 6-8.3. The call duration varied from 1.2-3.6s. Pulse width range 72-167ms. Dominant frequency range 2.6- 3.8kHz. The first pulse of recordings FC 2,5,8,10 and 11 varied between 72-125ms and have a lower frequency range than proceeding pulses. Pulses peter out at 3.7-7kHz.

An analysis of these recordings has established that ♂♂ produce the fast chatter (FC5-FC10). ♀♀ have produced the chirp (CH1 and CH1a). When the combination of ♂♂ and ♀♀ was used for a recording, I was unable to ascertain which gecko called.

Conclusion

Gehyra dubia does frequently call. The calls heard and/ or analysed can be categorised into three distinct groups: 1) the distress, 2) the chirp, and 3) the fast chatter. Both sexes exhibit the distress call. The chirp call has also been produced by both ♂♂ & ♀♀. Pulses of the chirp call are often long (up to 228ms), lack intensity, and are exhibited as a single pulse or a series of pulses with long intervals between. The fast chatter has been strongly exhibited by ♂♂ only, and is frequently heard throughout my house. The amplitude of these pulses is high, and typically intensifies in the latter portion of the call (Fig. 1C). Pulses of the fast chatter are short (<167ms), and are carried out over a short period (<3.6s). Estimated dominant frequencies of the chirp and fast chatter calls are quite similar (2.6-3.8kHz). Differentiation between both types of calls includes, pulse rate, pulse width and call intensity.

Only one recording consisted of both the chirp and fast chatter calls - CHFC1, ♂ & ♀, sample 1 (four chirps followed instantly by 17 fast chatter pulses, Fig. 1B). By comparison to other recordings (CH1, CH1a and FC5-10), and the very short transition period from chirps to chatter, it is quite reasonable to suggest that the call of recording CHFC1 consists of a ♀ followed by a ♂. However, this would need to be verified by a higher sample rate.

The reasons for these calls are unknown. However, it does not seem unreasonable to speculate that they relate to sex recognition and territory definition and defence as has been postulated for many other animal calls.

Acknowledgements

For assistance in preparing this paper, thanks are due to Jeanette Covacevich for advice on the manuscript; Dr Mark Hutchinson (South Australian Museum) and Peter Robertson (Wildlife Profiles) both imparted their knowledge on sexual dimorphism within the gecko family; Jon Butterworth (Electrical Engineer, Queensland Cement Ltd) for guidance on the Gram 50 program and analysis on sound waves; Assoc. Prof. Ross Alford and Dr Lin Schwarzkopf of James Cook University for forwarding the Gram 50 program and sharing their knowledge on the analysis and identification of biological sounds. Special thanks to my wife Inge for tolerating the disturbances and inconvenience of such a study. John Toop of the Department of Environment and Heritage provided study permits.

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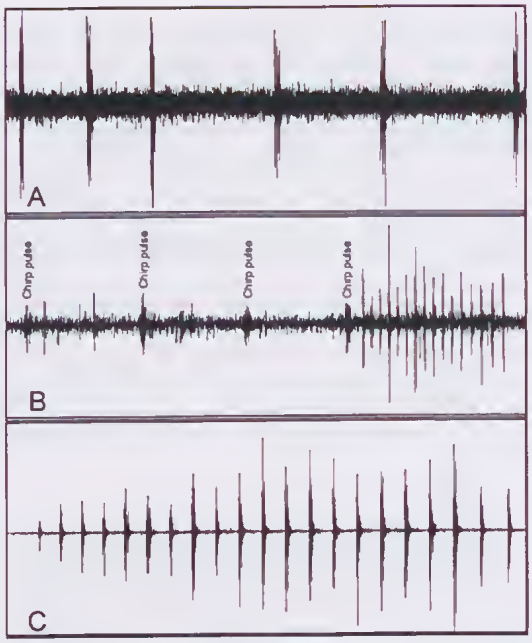

FIG. 1. Audiographs. A, CH1, sample1, 2♀♀, 6 pulses, call duration ~11.2s. B, CHFC1, sample 1, ♂ & ♀, call duration ~8.2s. C, FC10, sample 4, 2♂♂, 21 pulses, call duration ~3.6s.

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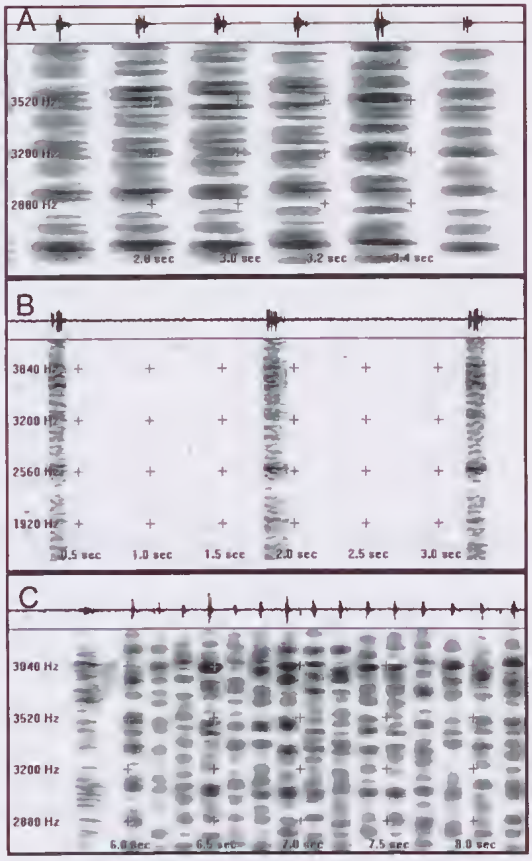

FIG. 2. Spectrographs. A, FC10, sample 4, 2♂♂, pulses 14-19, dominant frequency of pulses ~2.6kHz. B, CH1, sample 1, 2♀♀, pulses 1-3, dominant frequency of pulses ~3.8, 2.6 & 2.6kHz. C, CHFC1, sample 1, ♂ & ♀, pulses 4-20, chirp and chatter transition, dominant frequency of pulses ~3.8kHz. Darker shades indicate higher decibel readings.

TABLE 1. Recording data. LR, low resolution.

Rec. No.	Sex & sample No.	Pulses/ call duration (sec.)	Pulses/ sec.	Pulse width (msec.)	Estimated dominant frequency (kHz)
FC1	♂ & ♀, s1	12/1.7	7	87-133	3.0
FC2	♂ & ♀, s1	9/1.5	6	87-156	2.6
FC3	♂ & ♀, s1	11/1.5	7.3	LR	LR
FC4	♂ & ♀, s1	17/2.5	6.8	LR	LR
FC5	2 ♂, s3	10/1.2	8.3	76-114	3.8
FC6	2 ♂, s3	18/2.2	8.2	LR	3.1
FC7	2 ♂, s3	23/2.9	7.9	LR	LR
FC8	2 ♂, s4	19/3.4	5.6	72-167	3.8
FC9	2 ♂, s4	20/3.4	5.9	76-167	2.6
FC10	2 ♂, s4	21/3.6	5.8	125-156	2.6
FC11	♂ & ♀, s5	18/3.3	5.5	87-163	3.6

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